NAVAL POSTGRADUATE SCHOOL
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TRANSONIC CASCADE WIND TUNNEL MODIFICATION AND INITIAL TESTS

by

Karl Ferdinand Volland, Jr.

June 1980

Thesis Advisor: R. P. Shreeve

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The transonic cascade wind tunnel at the Turbomachinery Laboratory was modified by incorporting a perforated wall section in the upper nozzle block. The purpose of this modification was to cancel the oblique shock waves from the cascade blades and to aid in starting the supersonic flow in the tunnel. Test results indicated that the modification performed successfully. Supersonic flow was established through the cascade blading which models the relative flow at the tip of the laboratory's transonic compressor. A

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TRANSONIC CASCADE WIND TUNNEL MODIFICATION AND INITIAL TESTS

by

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Submitted in partial fulfillment of
the requirements for the degree of

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from the

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June 1980

ABSTRACT

The transonic cascade wind tunnel at the Turbomachinery Laboratory was modified by incorporating a perforated wall section in the upper nozzle block. The purpose of this modification was to cancel the oblique shock waves from the cascade blades and to aid in starting the supersonic flow in the tunnel. Test results indicated that the modification performed successfully. Supersonic flow was established through the cascade blading which models the relative flow at the tip of the laboratory's transonic compressor. A butterfly valve must yet be installed in the cascade exhaust to produce back pressures corresponding to the compressor's transonic operation.

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NOMENCLATURE

English Letter Symbols

a - Short Side of Rectangle, in.

E - Modulus of Elasticity

K - Wall Factor (a function of wall geometry and Mach No.)

M - Mach Number

P - Pressure, lbf/in^2

q - Dynamic Pressure, lbf/in^2

R - Open Area Ratio

S - Stress, lbf/in^2

s - Blade Spacing

t - Plate Thickness, in.

w - Deflection, in

z - Scale Factor

Greek Letter Symbols

α - Stress Coefficient

β - Deflection Coefficient

Δ - Finite Difference

θ - Flow Inclination Angle Behind Oblique Shock

γ - Stagger Angle

ϕ - Camber Angle

Subscripts

Ø - Tunnel Air Supply Plenum

t - Total or Stagnation

m - Maximum

ACKNOWLEDGEMENT

The work presented here was supported by significant contributions from many individuals. Their knowledge and dedication made the successful modification and testing of the Transonic Cascade Wind Tunnel possible.

Mr. Glen Middleton provided his expertise to the design and fabrication of the tunnel modification. Mr. Jim Hammer lent his competance as an experimentalist to the project, while Mr. John Morris and Mr. Steve Downey contributed to this work in the area of test set-up and configuration change. Mr. Alan McGuire dedicated his time and effort to insuring that a proper Engineering approach be adhered to in all phases of this work from modification design through the preparation of this report.

Associate Professor R. P. Shreeve offered the challenge and provided the overall guidance for this project, and created a dynamic and professional working environment. Without the efforts of each of these gentlemen this work could not have been completed.

I. INTRODUCTION

The purpose of the work reported here was to modify and perform the initial testing of the small transonic cascade wind tunnel model as one task in the Transonic Compressor Research Program at the Naval Postgraduate School (NPS), Monterey, California. The cascade wind tunnel model was constructed in 1978 [Reference 1] in Building 230 at the NPS Turbopropulsion Laboratory. Preliminary blowdown tests were made through the empty nozzle [Reference 2]. Safe operation and good pressure control at a stagnation pressure of 50 psia for test times of up to 2 mins were verified. Impact pressure probe surveys on the vertical centerline at the nozzle exit showed the flow to be uniform to with $\pm$ 0.008 at a Mach number of 1.415.

The goals achieved in the present study were to design and install a porous wall section in the upper nozzle block, install the test blading and then to conduct the first experimental evaluation of the completed cascade model. Details of the porous-wall modification made to the nozzle are given in Appendix A. A modification made in the design of the cascade blade mounts to simplify the assembly of the cascade, is also given in Appendix A.

Following the modifications, a program of tests was run which was in three parts. First, Calibration Tests of

the empty wind tunnel were conducted to verify tunnel operating conditions, and to establish a baseline for the pressure distribution through the test section. Following the Calibration Tests the cascade blades were installed and a series of initial Cascade Tests was conducted which verified that the blades and blade mounts and the perforated wall section had adequate strength, that the cascade model would "start" with the perforated wall vented to atmosphere, and that the scoops and by-pass ducts also worked properly. Detailed data was obtained and is discussed herein. Finally, the blades but not the scoops were removed and Wave Cancellation Tests were run to evaluate the effectiveness of the porous wall.

The instrumentation used in the tests consisted mainly of 89 static pressure taps distributed over the cascade side walls. Data was recorded and immediately analyzed using a Hewlett-Packard Model HP-3052/9845A data acquisition system interfaced with two 48 port Scanivalves. Software developed for the tests is detailed in Appendix B.

The body of the present document details the method and results of the three sets of tests. In Section II, the Cascade Wind Tunnel Model and instrumentation system are explained. In Section III, the test program and procedures are presented. An analysis of the results is presented in Section IV. Concluding remarks and recommendations are presented in Section V.

II. CASCADE WIND TUNNEL MODEL AND INSTRUMENTATION

A. INSTALLATION

Views of the Cascade Wind Tunnel installation are given in the four sections of Figure 1. The installation was modified from that presented in Figure 5 of Reference 1. First, the butterfly valve shown in Reference 1 was not installed. Second, during the Calibration Tests of the empty tunnel the scoop exhausts and perforated wall plenum exhaust were capped. Finally, the initial Cascade Tests, with blades installed, were conducted with scoop exhausts and perforated wall plenum vented locally to atmospheric conditions.

The design Mach number and total pressure for the cascade wind tunnel model were 1.4 and 50 psia, respectively [Reference 1].

B. TEST SECTION

The test section configuration differed from that presented in Reference 1 because instrumented aluminum plates were used in place of the proposed plexiglass windows, and the upper nozzle block was modified to include a perforated wall section. The cascade configuration for each test is given in Section III.

C. INSTRUMENTATION

To measure nozzle and test section static pressures, a series of 89 static ports were installed in the aluminum side (window) plates, 74 on the front plate and 15 on the

rear plate as seen in Figures 1c and 1d. The static tap design is shown in Figure 2 which also shows the adopted system of axes. The coordinates of the ports are given in Table I.

The plenum total pressure was measured using a static tap in the plenum sidewall. (At design conditions of 50 psia and 520° R in the plenum, the static pressure and total pressure were negligibly different). All pressures were recorded by the data acquisition system (Appendix B) through two 48 port Scanivalves. One Scanivalve was equipped with a 0-15 psig the other with a 0-50 psig transducer. Both transducers were calibrated to read in psig to an accuracy of 0.01 psia.

The Scanivalve connections to the 89 test section ports are given in Table I. Ports 1 and 2 on each valve were connected to atmosphere and to the reference side of the transducer respectively. Port 3 on Scanivalve 1 was connected to plenum pressure. When the flow through the perforated wall was measured, the plenum exhaust static pressure and impact pressures were connected to ports 46 and 47 of Scanivalve 2 respectively.

III. TEST PROGRAM AND PROCEDURES

A. CALIBRATION TESTS

Test runs were made first with the tunnel test section configuration shown in Figure 3. Data from two runs are reported. The blades and scoops were removed, and the by-pass ducts and perforated wall plenum exhaust were capped. The tests were conducted to determine a baseline static pressure distribution in the test section. The first test also served to verify the nozzle operation at design conditions, and to verify that data could be obtained within the available tunnel run time.

B. CASCADE TESTS

Runs were made next with the tunnel configured as shown in Figure 4. Data from two runs are reported. The blades and scoops were installed with the flat sides (bottoms) of the blades aligned with the tunnel axis. The by-pass ducts and perforated wall plenum were vented to atmospheric conditions. The tests were conducted to verify that the flow would fully start through the cascade model at design pressure and to obtain first measurements. The effectiveness of and flow through the perforated section of the upper nozzle block were also evaluated. An estimate of the flow rate from the porous section was obtained using measurements of the static pressure

in the perforated wall plenum exhaust pipe and of the total pressure at the exit of the pipe.

One test run was made with the same test section configuration but with the perforated wall plenum exhaust capped.

C. WAVE CANCELLATION TESTS

The final runs were made with the blades removed and the scoops installed as shown in Figure 5. Data from the two tests are reported. The by-pass ducts and perforated wall plenum were vented to atmospheric conditions for the first run and capped for the second. These runs were made to set up a condition where just one shock wave was present in the test section in order to more easily evaluate the performance of the perforated wall in reducing shock reflections.

D. TEST PROCEDURE

The procedure followed in each test was the same. First the flow was started through the tunnel by opening the manual shut-off valve, followed by the pneumatically operated control valve (Figure 1b). The stagnation supply pressure was brought rapidly to, and controlled at 50 psia. ($\pm$ 2 psi in all tests). A single entry at the data system keyboard initiated the sequential stepping (and recording) of the Scanivalves through 96 ports. When the scan was completed, the control and shut-off valves were closed. The recorded data were first stored on magnetic

cartridge tape and then recovered by a data analysis program which generated plots of the measured pressure distributions.

IV. RESULTS AND DISCUSSION

A. DATA PRESENTATION

Fourteen tests were conducted in the present study. Six sets of experimental data, two from each of the three types of tests conducted, were analyzed and the results included herein. These data are presented in Appendix C.

B. DATA ANALYSIS

The flow in the cascade wind tunnel was examined by comparing the expected shockwave patterns [References 3 and 4] in the cascade with the measured distributions of the pressure ratio (P/P_{to}) at the wall. In a flow at Mach number 1.4 an oblique shock can result in a maximum static pressure rise of approximately 23 percent. A normal shock causes the static pressure to more than double. Comparison of pressure ratio data for ports at the same position but on opposite faces of the tunnel test section indicated that there was no significant difference at the two walls. Plots of pressure ratio along the tunnel longitudinal centerline and along the four rows of pressure taps upstream of the blades at the cascade stagger angle (Figure 6) were made and used to examine the tunnel flow characteristics.

It should be noted that the following is a preliminary and limited analysis of recently obtained data. The data points on each plot have been joined by straight lines. In some cases only, the more probable distribution between

points has been indicated by broken lines.

C. CALIBRATION TESTS

The expected primary wave pattern for this test configuration is shown in Figure 7. Since the nozzle was under-expanded, an expansion fan was expected from the end of the lower nozzle block and an oblique shock might occur from the lower nozzle block and an oblique shock might occur from the lower bypass protrusion. A plot of pressure ratio vs. position along the tunnel centerline is given in Figure 8a. In this figure, the expected expansion fan appeared clearly and a small compressive disturbance might also have been present. Plots of pressure ratio along the four diagonal rows of pressure taps are given in Figures 8b to 8e. The region covered by these taps was seen to be free of strong waves, and the effect of the expansion fan from the lower nozzle could be traced. Of considerable importance is the degree of uniformity observed in all the taps which were upstream of the expansion fan. This upstream region should be unaffected by the installation of the cascade blades. The results of the two calibration runs were compared and the results were observed to be repeatable.

D. CASCADE TESTS

1. Perforated Wall Plenum Exhaust Capped

The results of the test conducted with the tunnel in its design configuration with the perforated wall plenum capped resulted in the tunnel flow not starting at the design supply plenum total pressure of 50 psia. The pressure ratio

along the tunnel longitudinal centerline is shown in Figure 9. Examination of the levels of pressure suggested that the flow was choked (pressure ratio - 0.5282 if losses are neglected) at the throat of the blade passage and that the nozzle itself was operating subsonically at the test section.

2. Perforated Wall Plenum Vented to the Atmosphere

Allowing flow through the perforated section of the upper nozzle block by uncapping the exhaust resulted in the flow being fully started at the design plenum pressure of 50 psia. The expected flow with the blades and scoops installed is shown in Figure 10. The side-wall pressure distribution is shown in Figure 11a to Figure 11e. The effect of the shock waves generated by the blades can be seen by comparing the data in Figure 11 with the corresponding sections of Figure 8. A comparison of Figure 11a with Figure 8a, and of Figure 11b with Figure 8b showed that the pressure rise from the first shock wave (labelled A in Figure 11) began measurably ahead of the position of the shock wave shown in Figure 10. Also, if the pressure drop upstream of point B on Figure 11a, which was repeated on several other runs made with this configuration, was correctly interpreted to be the expansion caused by the upper surface of the nearest blade, then the bow shock from that blade also appeared to be shifted forwards. These effects may have been the result of shock wave-boundary layer interaction on the side walls, but closer examination of the data is

needed before definite conclusions are drawn. The probable distributions of pressure indicated in Figure 11a were inferred from the comparison with Figure 8a and with data obtained in the Wave Cancellation Tests.

For the data shown, the velocity at the exhaust port from the perforated wall plenum was calculated to be about 47 ft/sec and the mass flow rate was approximately 0.1 percent of the tunnel mass flow rate.

E. WAVE CANCELLATION TESTS

1. <u>Perforated Wall Plenum Vented to the Atmosphere</u>

The test section configuration and expected wave pattern are shown in Figure 12. The measured pressure distributions are shown plotted in Figure 13a to 13e. In Figure 13a, the (first) oblique shock wave was clearly indicated. The reflected shock wave did not appear, probably as a result of the strong expansion of the flow over the suction surface of the lower scoop.

The velocity at the plenum nozzle exit was approximately 12 ft/sec and the mass flow rate therefore significantly less than 0.1 percent of the tunnel mass flow rate.

2. <u>Perforated Wall Plenum Exhaust Capped</u>

The pressure distributions when the net flow rate through the perforated wall was reduced to zero are shown in Figure 14a to 14e.

An examination of the magnitudes of the pressure ratios in comparison to corresponding sections of Figure 13 showed that the effect of capping the exhaust was felt everywhere

downstream of a Mach wave emanating from the beginning of the perforated wall. The pressures were lower downstream of the Mach wave when the wall exhaust was open compared to when it was capped. It appeared therefore, that the effect of the unrestricted mass bleed was to propagate an additional expansion fan from the top wall across the test section.

F. STRUCTURAL INTEGRITY

The structural adequacy of the blades, blade mountings and upper nozzle block modification were verified at design operating conditions. No deterioration was evident after the reported program of tests was completed.

G. CASCADE PERFORMANCE

The cascade was designed as a model of the relative flow at the tip of the transonic compressor being tested at the Turbopropulsion Laboratory. The present results indicate that there was a net pressure drop rather than a pressure rise across the blade row, as occurs in the compressor. This was because the back pressure on the blades at a supply pressure of 50 psia was too low. A control on the back pressure is necessary in order to adjust the shock waves from the bottoms of the blades to become normal shocks ahead of the blade passage throats. An examination of the present data suggested that the shock waves off the bottom of the blades were, in fact, weak and oblique.

V. CONCLUSIONS AND RECOMMENDATIONS

This document reports the initial testing of the transonic cascade wind tunnel model. Detailed wall static pressure measurements were obtained both with and without test blades installed, and with and without flow from a perforated wall section newly installed in the upper nozzle wall.

All tests were at the design total pressure of 50 psia. Wave-free flow was verified at the exit of the empty nozzle, and repeatable reference data were established against which to evaluate the effect of installing the blades. With blades installed, expected bow shock waves and suction-side expansion fans were detected from the blading. However, lack of control on the back pressure allowed the flow to remain supersonic throughout the blade passages. The incorporation of the perforated wall in the upper nozzle block was found to be required in order for the flow in the tunnel to start when the blades were installed. The complete cascade wind tunnel model was structurally sound at design operating conditions.

Two modifications are recommended before testing is resumed. First, the butterfly-valve called for in the original design [Reference 1] should be installed in the cascade exhaust duct. The valve will allow the cascade back pressure to be varied over the range to be expected in

the flow through the compressor rotor, of which the cascade is a two-dimensional model. Second, an optical window sould either replace or be incorporated into the present aluminum window plates. The flow visualization by Schlieren which the windows would allow, would greatly simplify the problem of evaluating effects of back pressure and perforated wall bleed rates on the wave structure in the cascade. This could greatly simplify the problem of optimizing the wave cancellation function of the perforated wall, and of selecting conditions at which detailed pressure, and possibly probe data, should be recorded.

ANIVALVE NO. 1

ONT FACE

V Port No. 3	Pressure Tap No. 1	X =-3.318 inches	Y= 0.000 inches
V Port No. 4	Pressure Tap No. 2	X =-2.905 inches	Y= 0.000 inches
V Port No. 5	Pressure Tap No. 3	X =-2.618 inches	Y= 0.000 inches
V Port No. 6	Pressure Tap No. 4	X =-4.246 inches	Y=-1.344 inches
V Port No. 7	Pressure Tap No. 5	X =-3.082 inches	Y= -.672 inches
V Port No. 8	Pressure Tap No. 6	X =-2.306 inches	Y= -.224 inches
V Port No. 9	Pressure Tap No. 7	X =-2.112 inches	Y= -.112 inches
V Port No. 10	Pressure Tap No. 8	X =-1.918 inches	Y= 0.000 inches
V Port No. 11	Pressure Tap No. 9	X =-1.724 inches	Y= .112 inches
V Port No. 12	Pressure Tap No. 10	X =-1.530 inches	Y= .224 inches
V Port No. 13	Pressure Tap No. 11	X = -.754 inches	Y= .672 inches
V Port No. 14	Pressure Tap No. 12	X = .410 inches	Y= 1.344 inches
V Port No. 15	Pressure Tap No. 13	X =-3.546 inches	Y=-1.344 inches
V Port No. 16	Pressure Tap No. 14	X =-2.382 inches	Y= -.672 inches
V Port No. 17	Pressure Tap No. 15	X =-1.606 inches	Y= -.224 inches
V Port No. 18	Pressure Tap No. 16	X =-1.412 inches	Y= -.112 inches
V Port No. 19	Pressure Tap No. 17	X =-1.218 inches	Y= 0.000 inches
V Port No. 20	Pressure Tap No. 18	X =-1.024 inches	Y= .112 inches
V Port No. 21	Pressure Tap No. 19	X = -.830 inches	Y= .224 inches
V Port No. 22	Pressure Tap No. 20	X = -.054 inches	Y= .672 inches
V Port No. 23	Pressure Tap No. 21	X = 1.110 inches	Y= 1.344 inches
V Port No. 24	Pressure Tap No. 22	X =-2.846 inches	Y=-1.344 inches
V Port No. 25	Pressure Tap No. 23	X =-1.682 inches	Y= -.672 inches
V Port No. 26	Pressure Tap No. 24	X = -.905 inches	Y= -.224 inches
V Port No. 27	Pressure Tap No. 25	X = -.712 inches	Y= -.112 inches
V Port No. 28	Pressure Tap No. 26	X = -.518 inches	Y= 0.000 inches
V Port No. 29	Pressure Tap No. 27	X = -.324 inches	Y= .112 inches
V Port No. 30	Pressure Tap No. 28	X = -.130 inches	Y= .224 inches
V Port No. 31	Pressure Tap No. 29	X = .646 inches	Y= .672 inches
V Port No. 32	Pressure Tap No. 30	X = 1.810 inches	Y= 1.344 inches
V Port No. 33	Pressure Tap No. 31	X =-2.594 inches	Y=-1.344 inches
V Port No. 34	Pressure Tap No. 32	X =-1.430 inches	Y= -.672 inches
V Port No. 35	Pressure Tap No. 33	X = -.654 inches	Y= -.224 inches
V Port No. 36	Pressure Tap No. 34	X = -.460 inches	Y= -.112 inches
V Port No. 37	Pressure Tap No. 35	X = -.266 inches	Y= 0.000 inches
V Port No. 38	Pressure Tap No. 36	X = -.052 inches	Y= .112 inches
V Port No. 39	Pressure Tap No. 37	X = .122 inches	Y= .224 inches
V Port No. 40	Pressure Tap No. 38	X = .898 inches	Y= .672 inches
V Port No. 41	Pressure Tap No. 39	X = 2.062 inches	Y= 1.344 inches
V Port No. 42	Pressure Tap No. 40	X = -.388 inches	Y= -.224 inches
V Port No. 43	Pressure Tap No. 41	X = -.194 inches	Y= -.112 inches
V Port No. 44	Pressure Tap No. 42	X = 0.000 inches	Y= 0.000 inches
V Port No. 45	Pressure Tap No. 43	X = .194 inches	Y= .112 inches
V Port No. 46	Pressure Tap No. 44	X = .388 inches	Y= .224 inches
V Port No. 47	Pressure Tap No. 45	X = .050 inches	Y= .112 inches
V Port No. 48	Pressure Tap No. 46	X = .224 inches	Y= 0.000 inches

Table I. Cascade Wind Tunnel Static Pressure Tap Positions and Scanivale Port Connections

ANIVALVE NO. 2

V Port No. 3	Pressure Tap No. 47	X = .050 inches	Y= -.112 inches
V Port No. 4	Pressure Tap No. 48	X = .224 inches	Y= 0.000 inches
V Port No. 5	Pressure Tap No. 49	X = .438 inches	Y= .112 inches
V Port No. 6	Pressure Tap No. 50	X = .632 inches	Y= .224 inches
V Port No. 7	Pressure Tap No. 51	X = .138 inches	Y= -.224 inches
V Port No. 8	Pressure Tap No. 52	X = .330 inches	Y= -.112 inches
V Port No. 9	Pressure Tap No. 53	X = .524 inches	Y= 0.000 inches
V Port No. 10	Pressure Tap No. 54	X = .718 inches	Y= .112 inches
V Port No. 11	Pressure Tap No. 55	X = .388 inches	Y= -.224 inches
V Port No. 12	Pressure Tap No. 56	X = .582 inches	Y= -.112 inches
V Port No. 13	Pressure Tap No. 57	X = .776 inches	Y= 0.000 inches
V Port No. 14	Pressure Tap No. 58	X = .970 inches	Y= .112 inches
V Port No. 15	Pressure Tap No. 59	X = .856 inches	Y= -.112 inches
V Port No. 16	Pressure Tap No. 60	X = 1.050 inches	Y= 0.000 inches
V Port No. 17	Pressure Tap No. 61	X = 1.244 inches	Y= .112 inches
V Port No. 18	Pressure Tap No. 62	X = 1.438 inches	Y= .224 inches
V Port No. 19	Pressure Tap No. 63	X = 1.194 inches	Y= -.224 inches
V Port No. 20	Pressure Tap No. 64	X = 1.388 inches	Y= -.112 inches
V Port No. 21	Pressure Tap No. 65	X = 1.582 inches	Y= 0.000 inches
V Port No. 22	Pressure Tap No. 66	X = 1.776 inches	Y= .112 inches
V Port No. 23	Pressure Tap No. 67	X = .022 inches	Y=-1.344 inches
V Port No. 24	Pressure Tap No. 68	X = 1.126 inches	Y= -.672 inches
V Port No. 25	Pressure Tap No. 69	X = 2.350 inches	Y= 0.000 inches
V Port No. 26	Pressure Tap No. 70	X = 3.574 inches	Y= .672 inches
V Port No. 27	Pressure Tap No. 71	X = 4.678 inches	Y= 1.344 inches
V Port No. 28	Pressure Tap No. 72	X =-2.905 inches	Y= 1.630 inches
V Port No. 29	Pressure Tap No. 73	X =-2.905 inches	Y=-1.850 inches
V Port No. 30	Pressure Tap No. 74	X = 2.905 inches	Y= 1.828 inches

EAR FACE

V Port No. 29	Pressure Tap No. 75	X =-5.360 inches	Y= 0.000 inches
V Port No. 30	Pressure Tap No. 76	X =-2.905 inches	Y= 0.000 inches
V Port No. 31	Pressure Tap No. 77	X =-2.594 inches	Y=-1.344 inches
V Port No. 32	Pressure Tap No. 78	X =-1.430 inches	Y= -.672 inches
V Port No. 33	Pressure Tap No. 79	X = -.266 inches	Y= 0.000 inches
V Port No. 34	Pressure Tap No. 80	X = .898 inches	Y= .672 inches
V Port No. 35	Pressure Tap No. 81	X = 2.062 inches	Y= 1.344 inches
V Port No. 36	Pressure Tap No. 82	X = .022 inches	Y=-1.344 inches
V Port No. 37	Pressure Tap No. 83	X = 1.126 inches	Y= -.672 inches
V Port No. 38	Pressure Tap No. 84	X = 2.350 inches	Y= 0.000 inches
V Port No. 39	Pressure Tap No. 85	X = 3.574 inches	Y= .672 inches
V Port No. 40	Pressure Tap No. 86	X = 4.678 inches	Y= 1.344 inches
V Port No. 41	Pressure Tap No. 87	X =-2.905 inches	Y= 1.630 inches
V Port No. 42	Pressure Tap No. 88	X =-2.905 inches	Y=-1.850 inches
V Port No. 43	Pressure Tap No. 89	X = 2.905 inches	Y= 1.828 inches

Table I. (Continued)

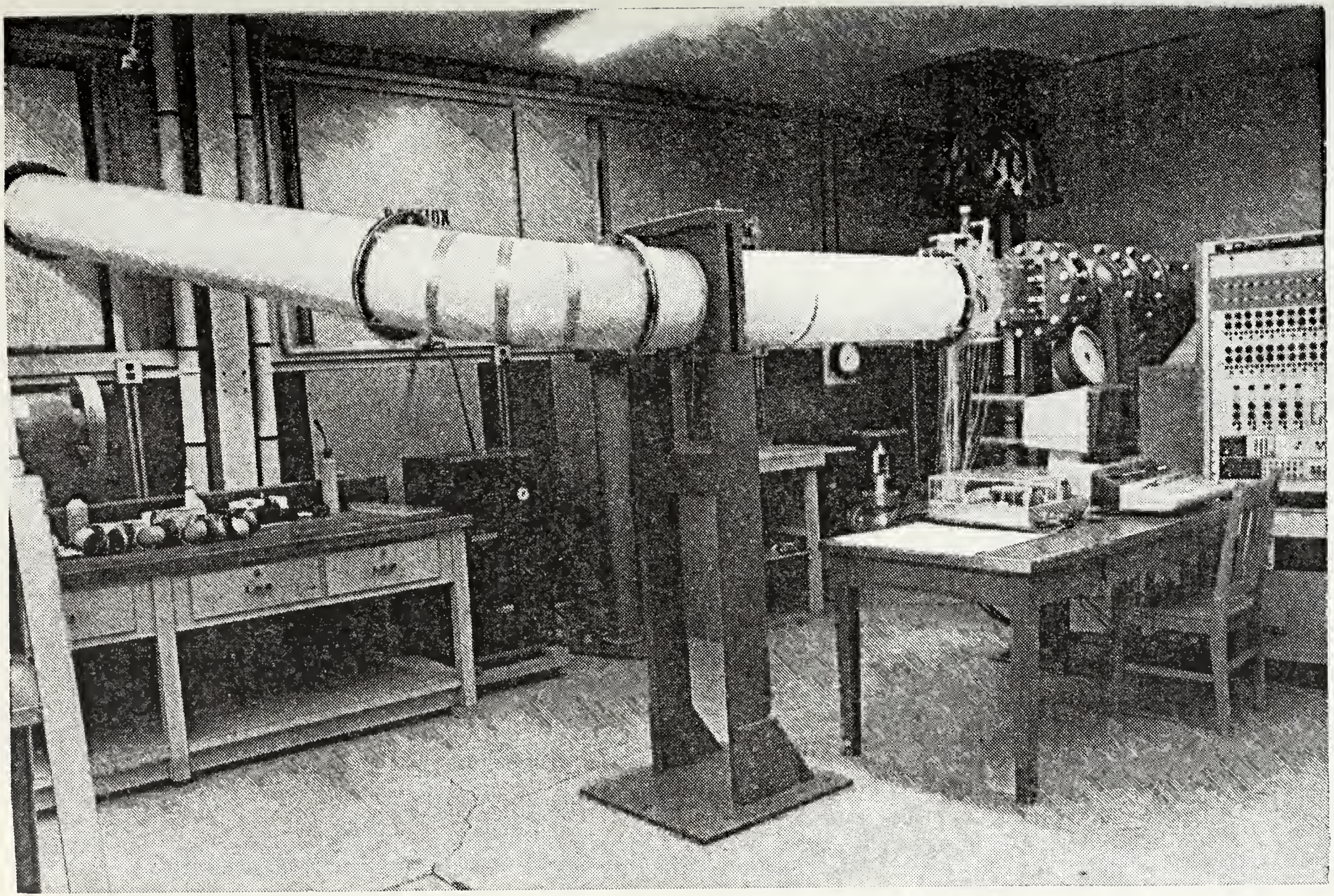


Figure 1a Cascade Wind Tunnel Model Installation
Laboratory View

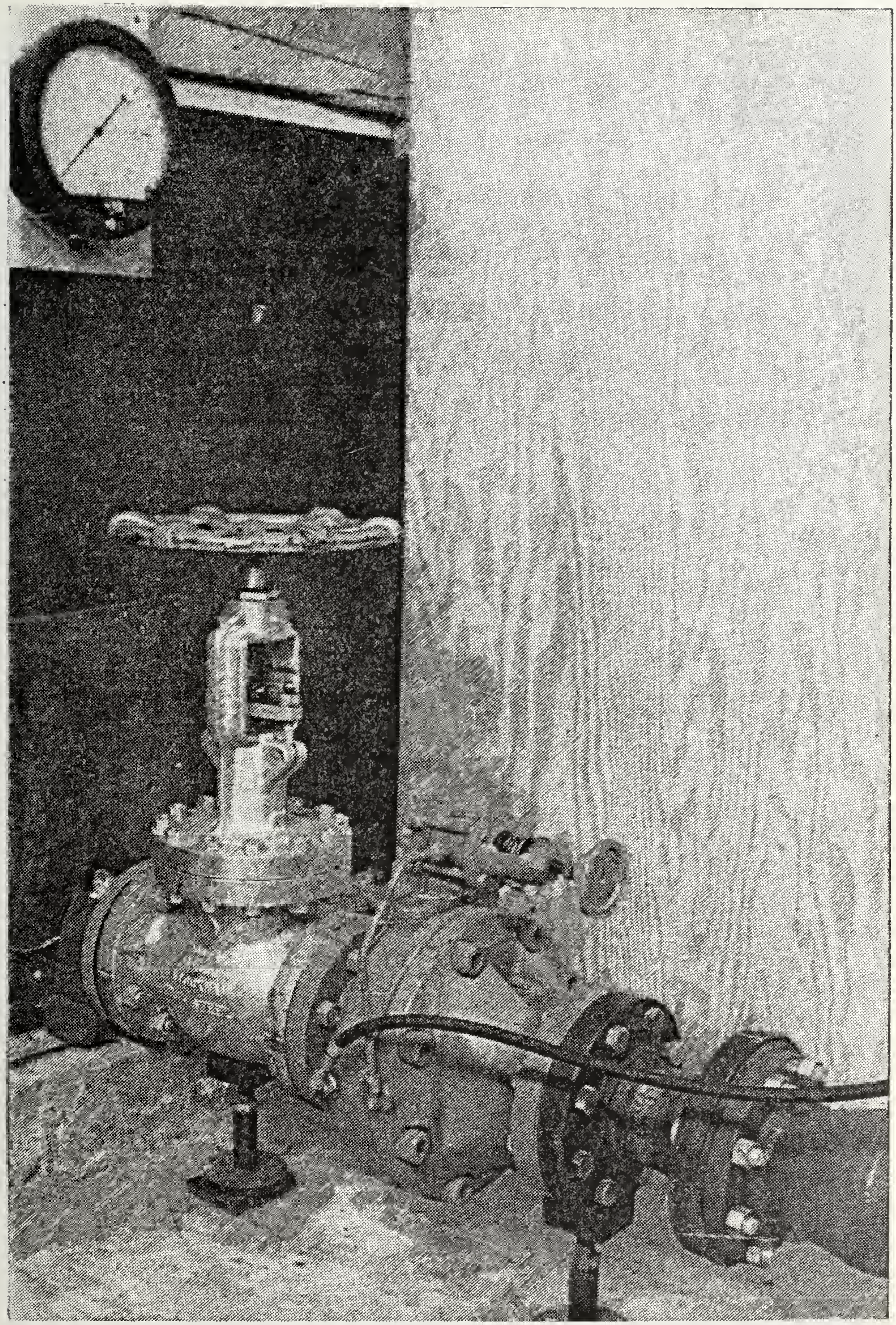


Figure 1b Cascade Wind Tunnel Model Installation
Air Supply Valves

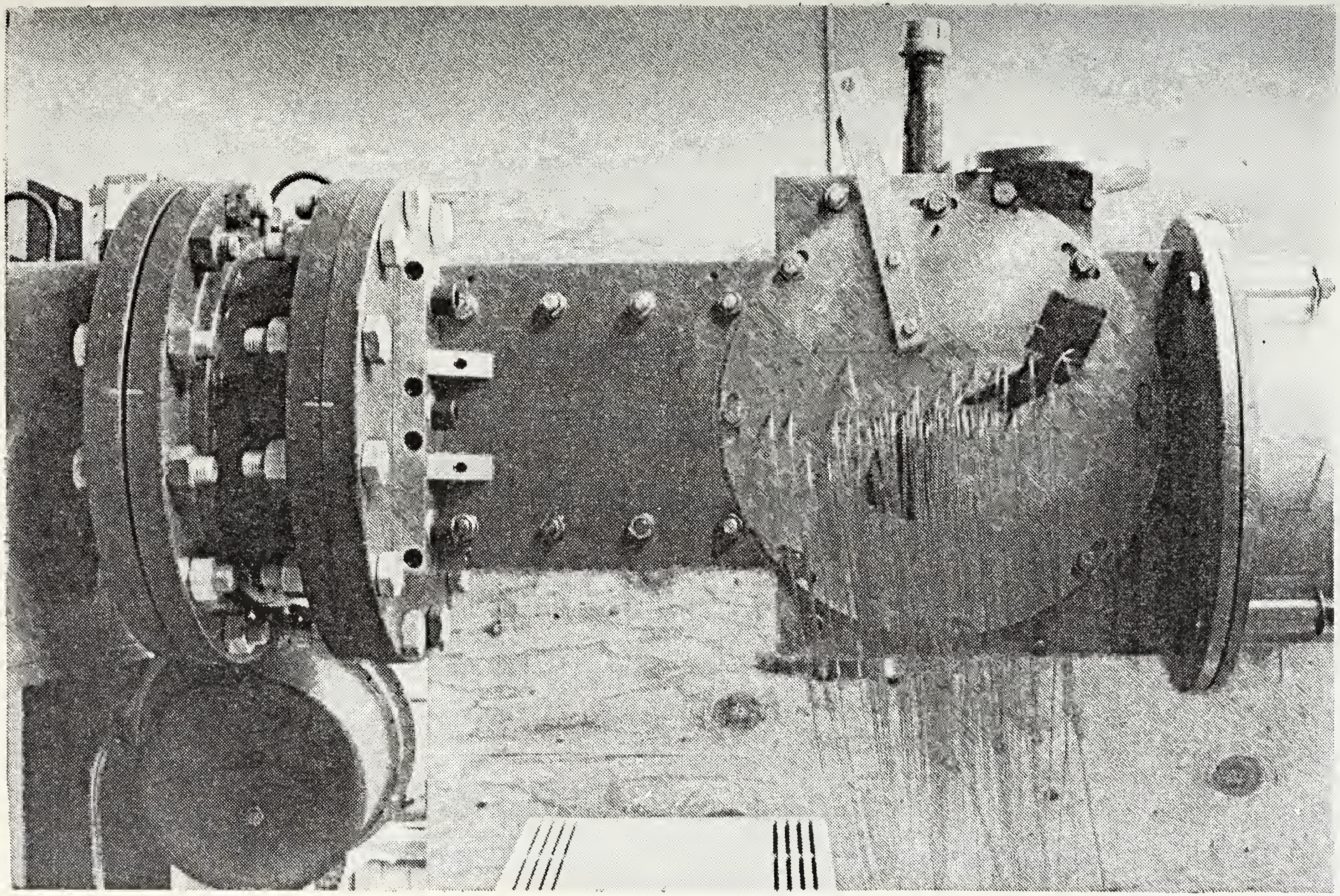


Figure 1c Cascade Wind Tunnel Model Installation
South side of Test Section

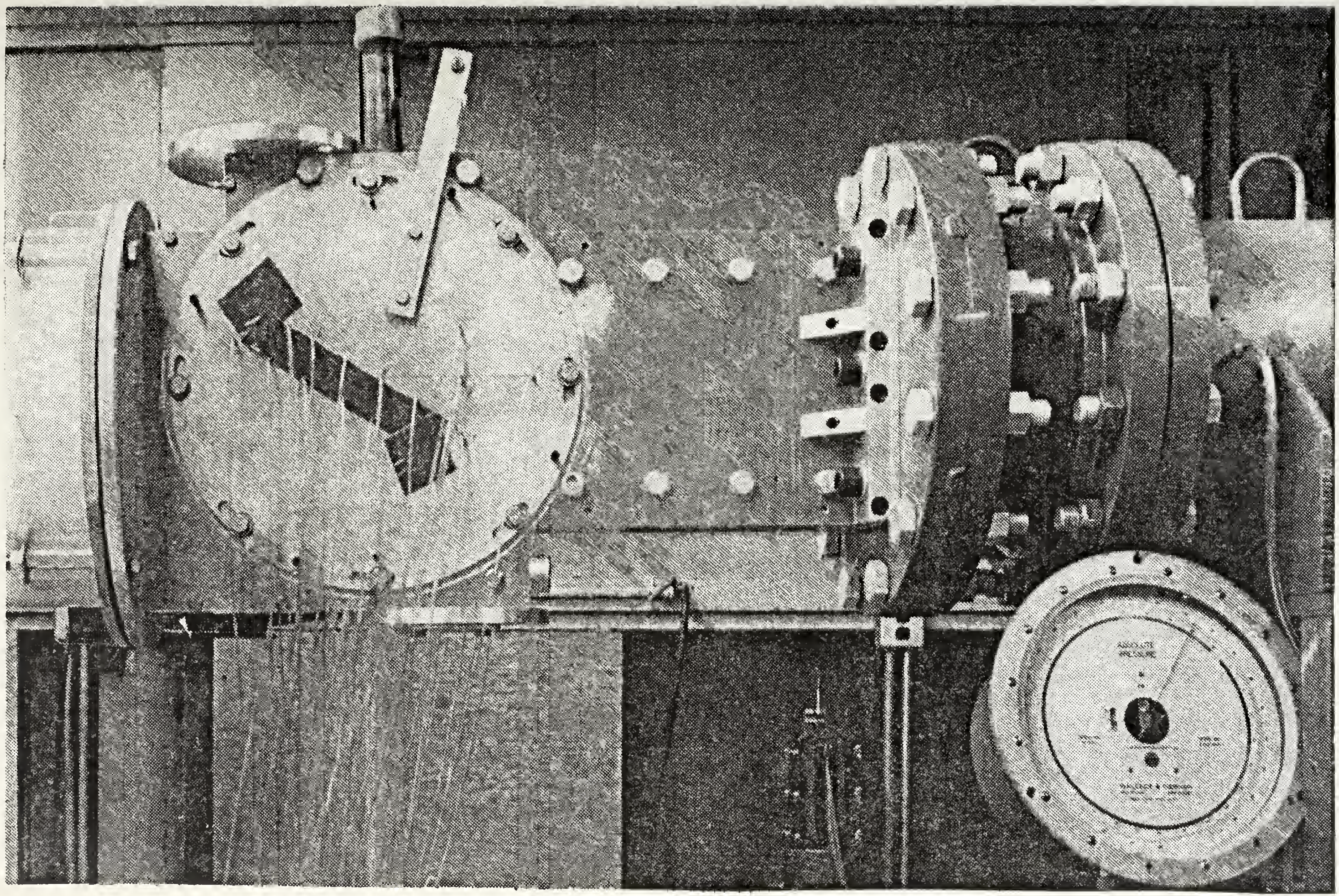


Figure 1d Cascade Wind Tunnel Model Installation
North Side of Test Section

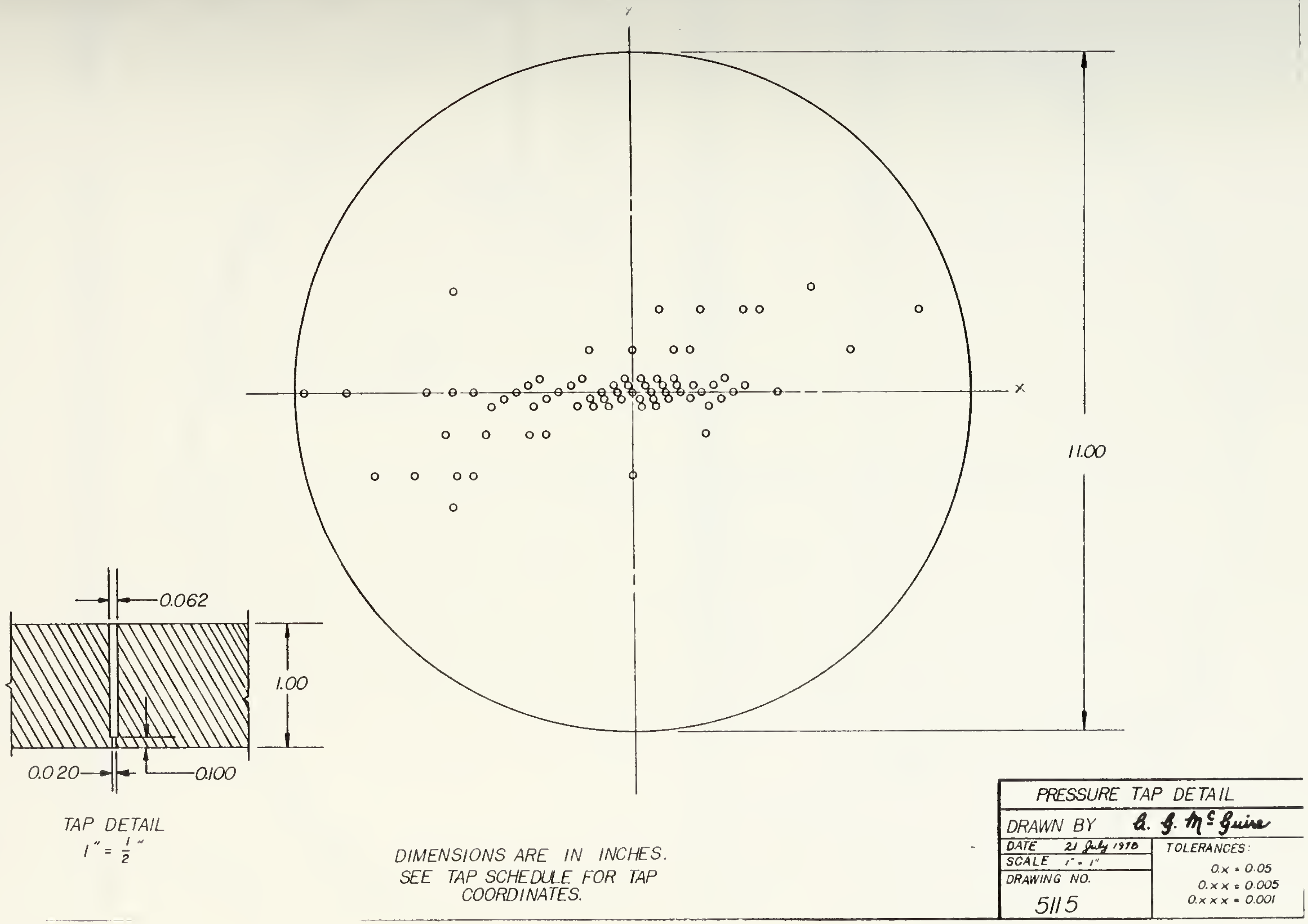


Figure 2 Cascade Wind Tunnel Test Section Static Pressure Tap Positions

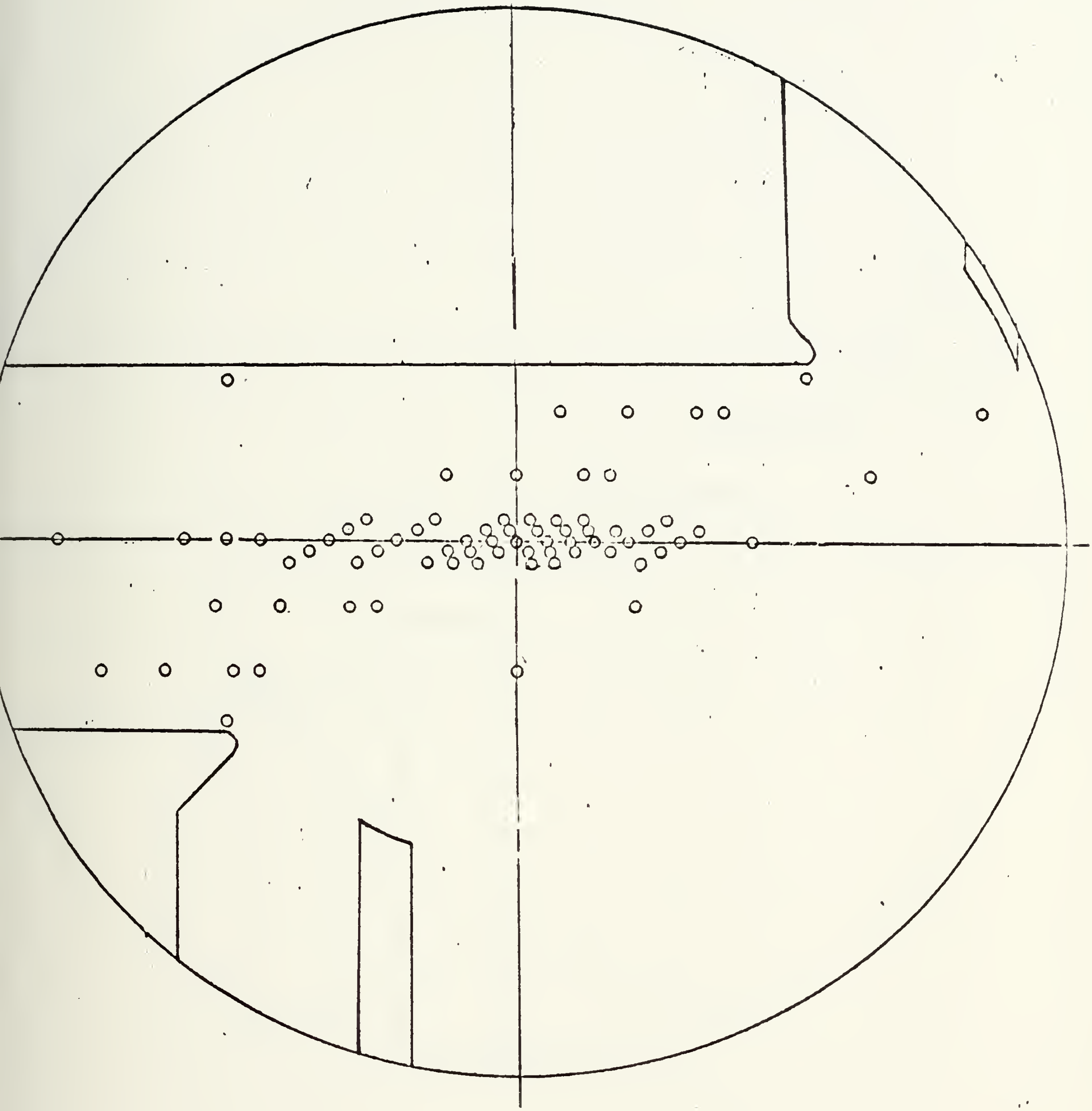


Figure 3. Test Section Configuration for Calibration Tests

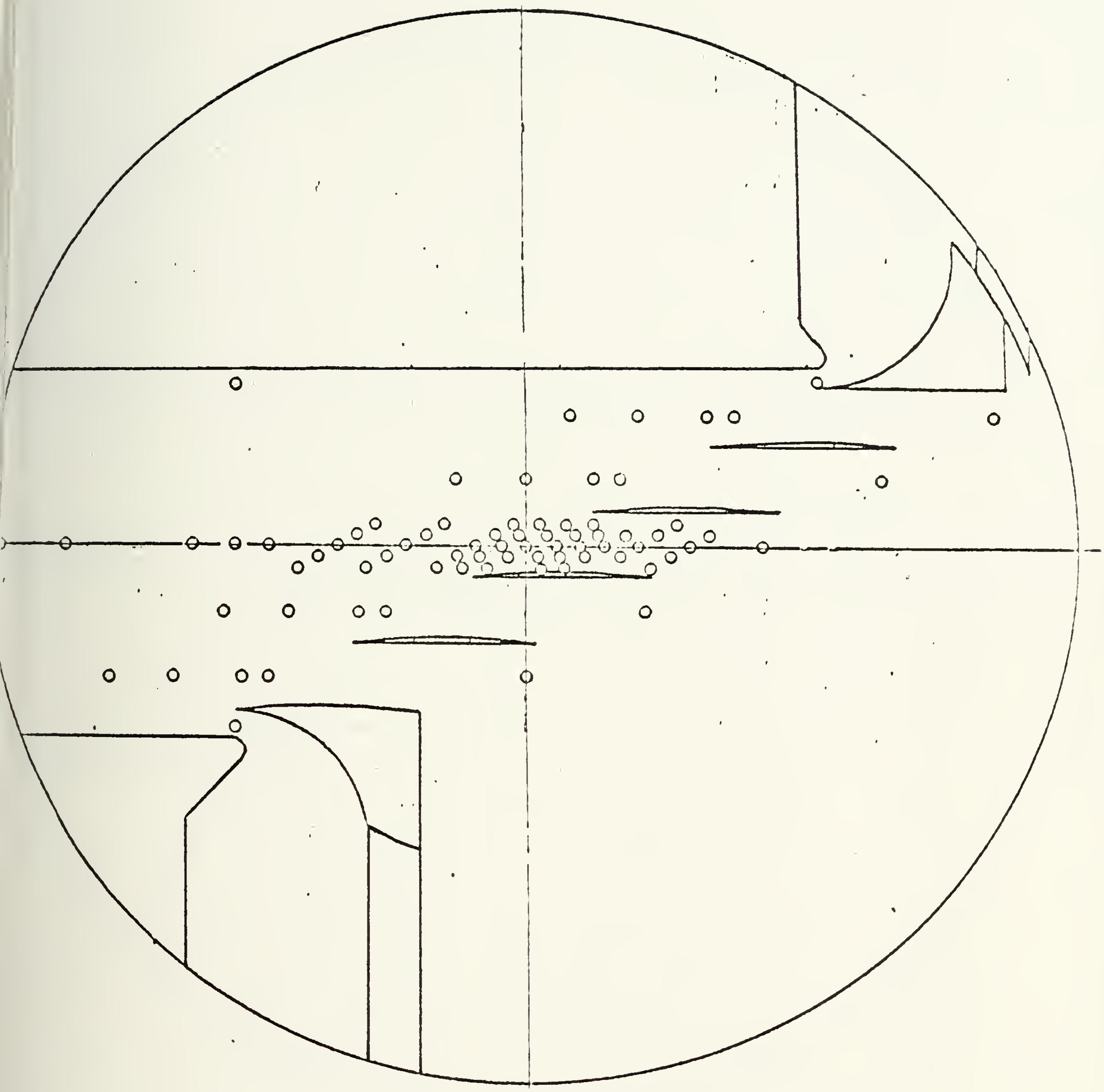


Figure 4. Test Section Configuration for Initial Cascade Tests

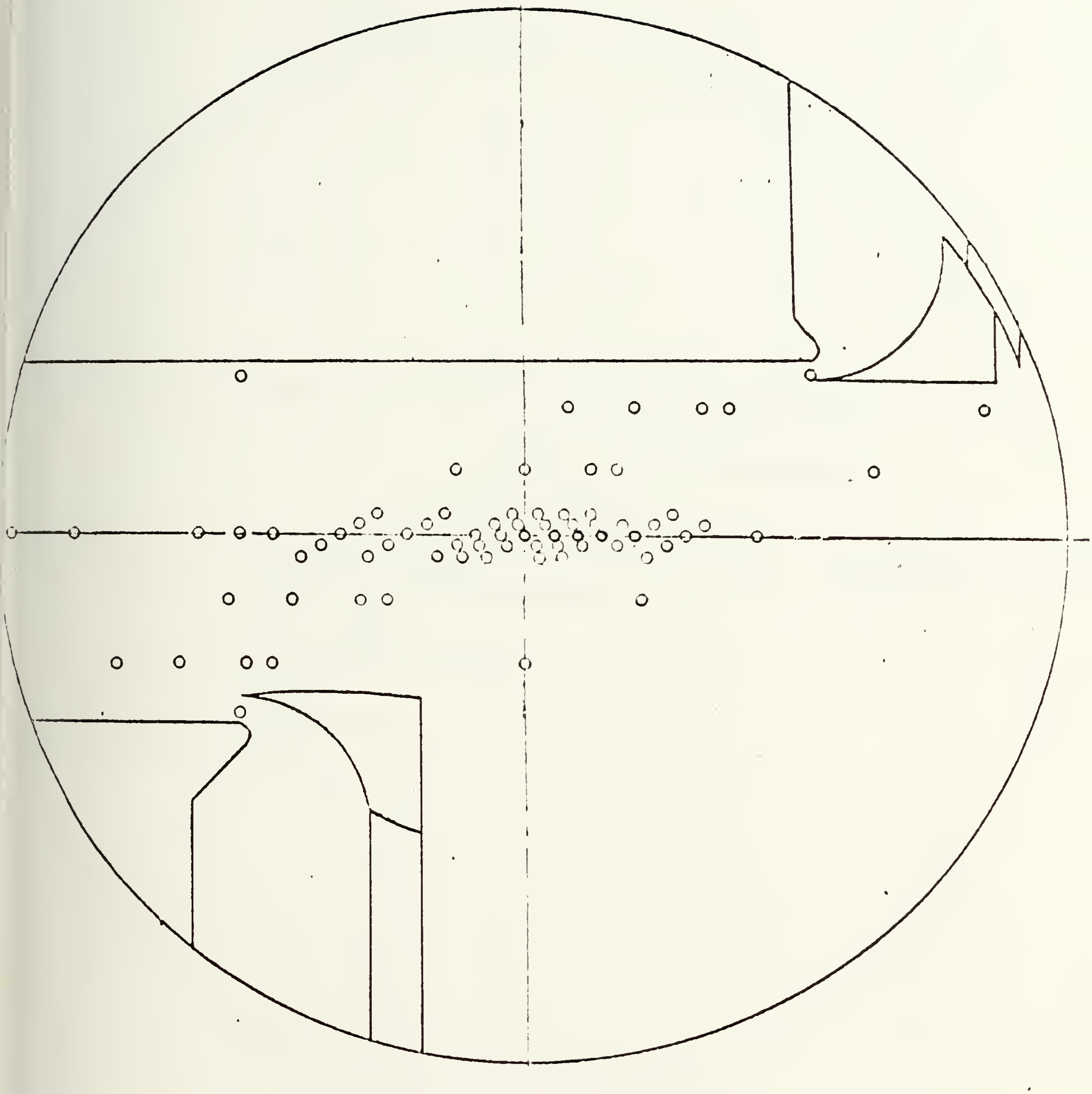


Figure 5. Test Section Configuration for Wave Cancellation Tests

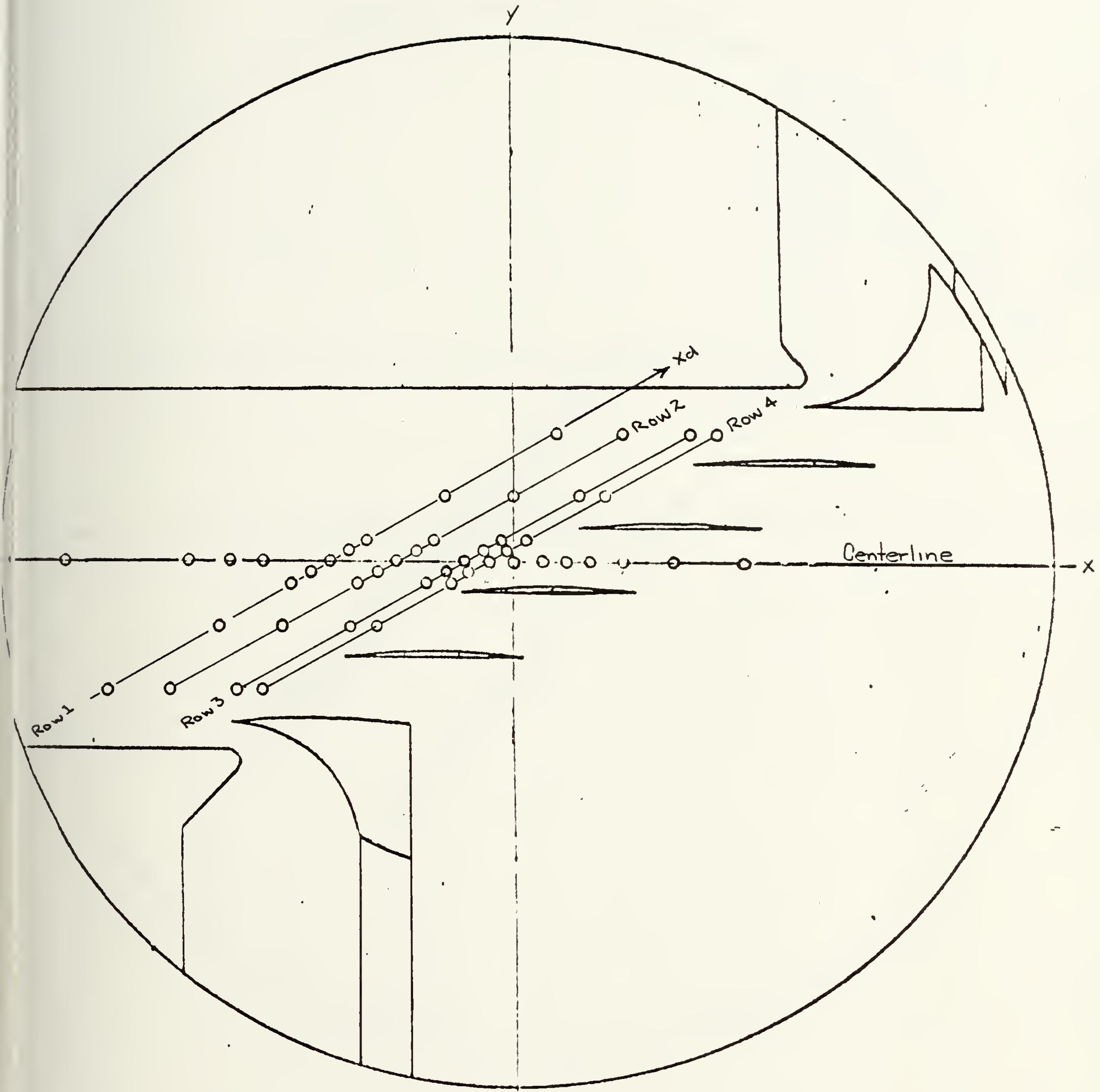


Figure 6. Centerline and Four Diagonal Rows of Static Pressure Taps for Which Data are Plotted

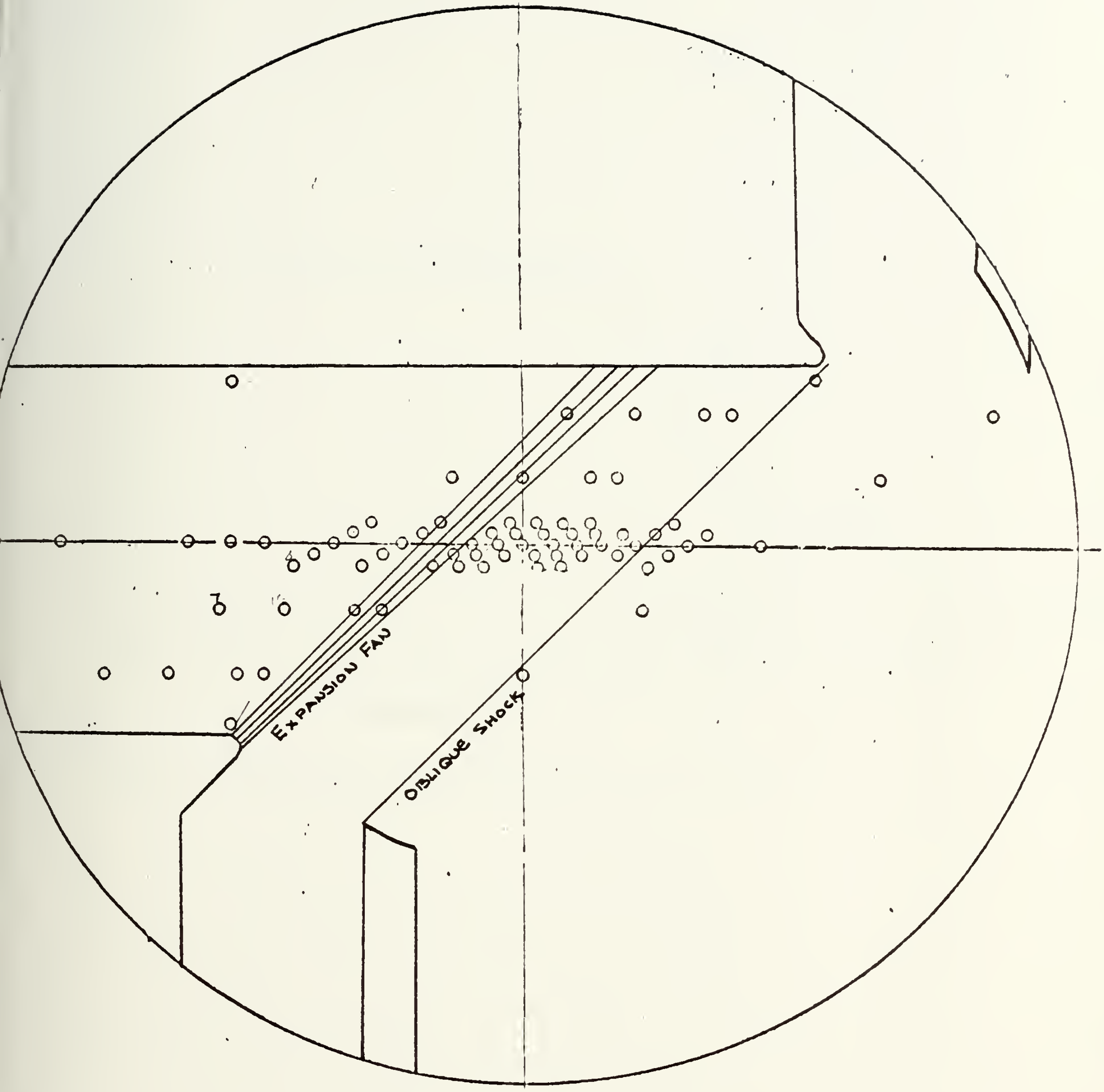


Figure 7. Expected Test Section Wave Pattern (Calibration Tests)

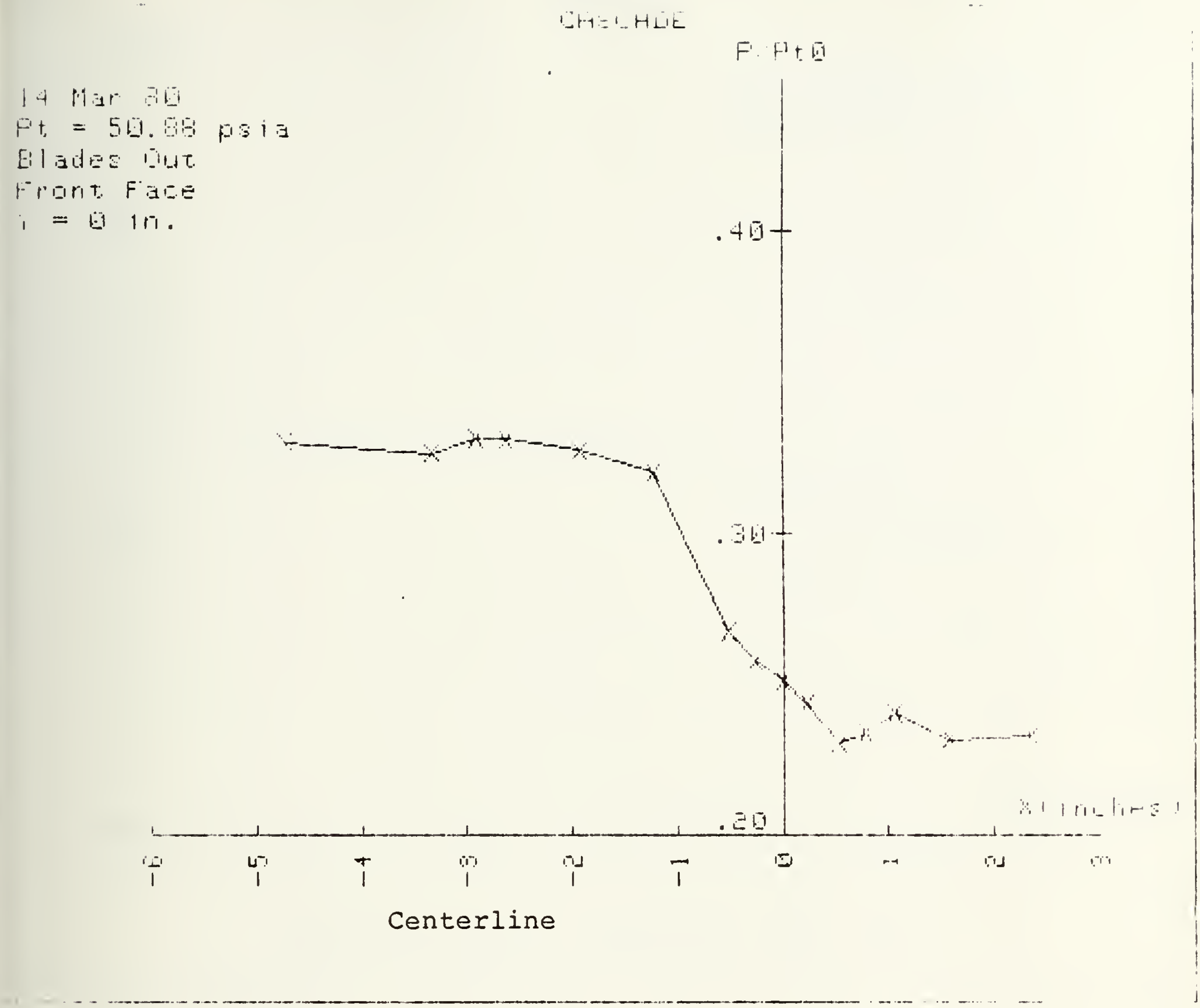


Figure 8a. Pressure Ratio vs. Position (Calibration Tests)

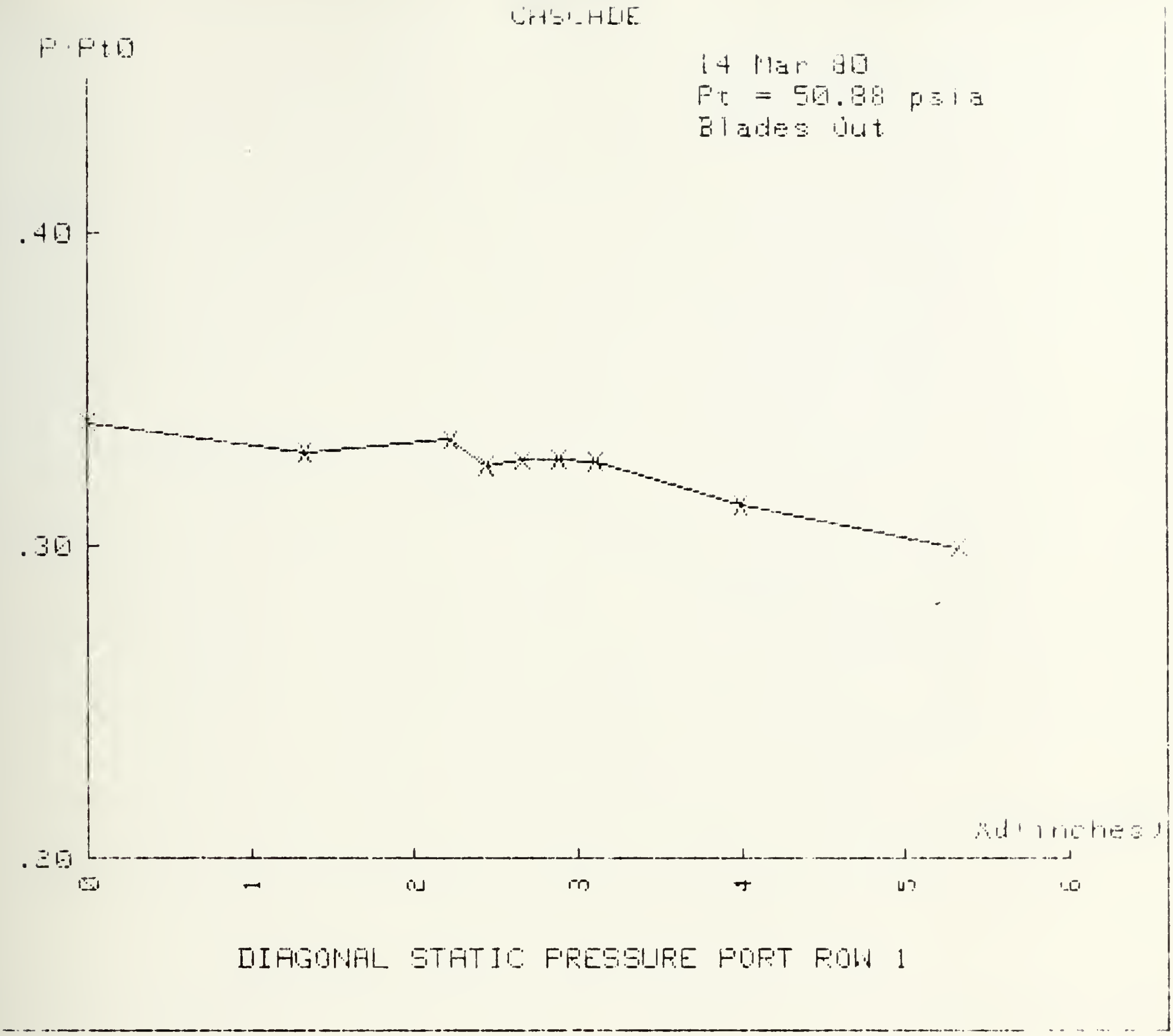


Figure 8b. Pressure Ratio vs. Position (Calibration Test)

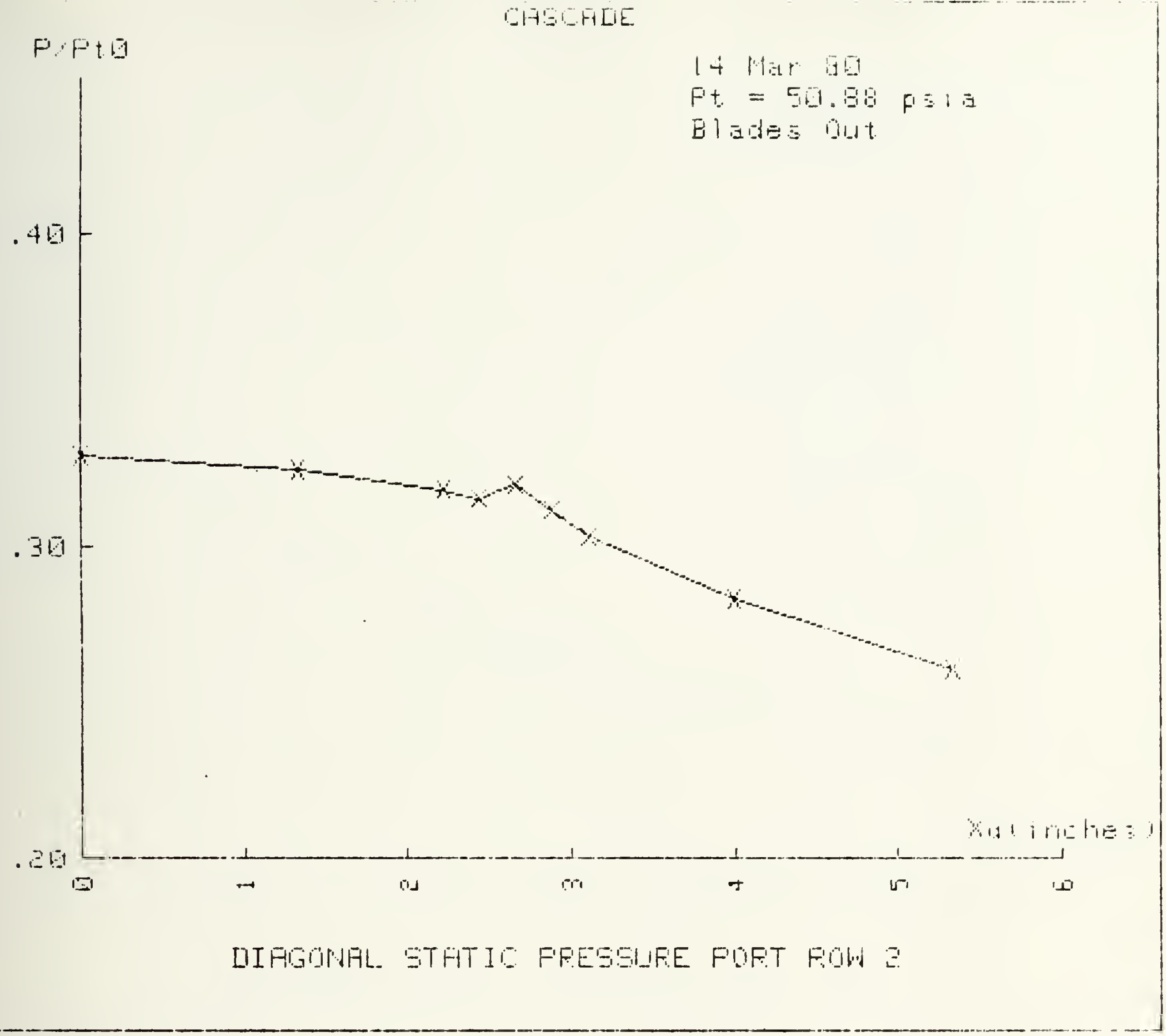


Figure 8c. Pressure Ratio vs Position (Calibration Test)

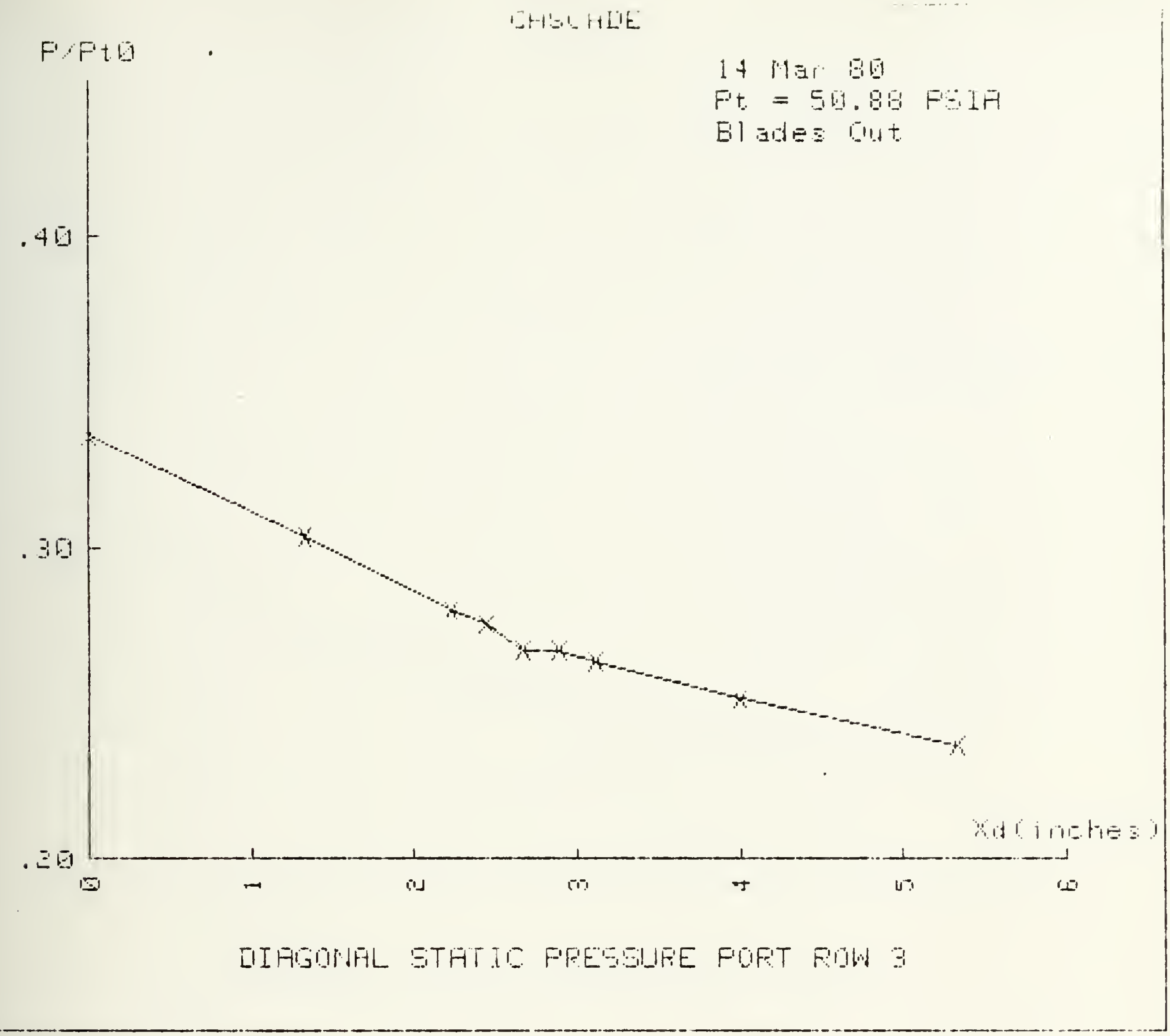


Figure 8d. Pressure Ratio vs. Position (Calibration Tests)

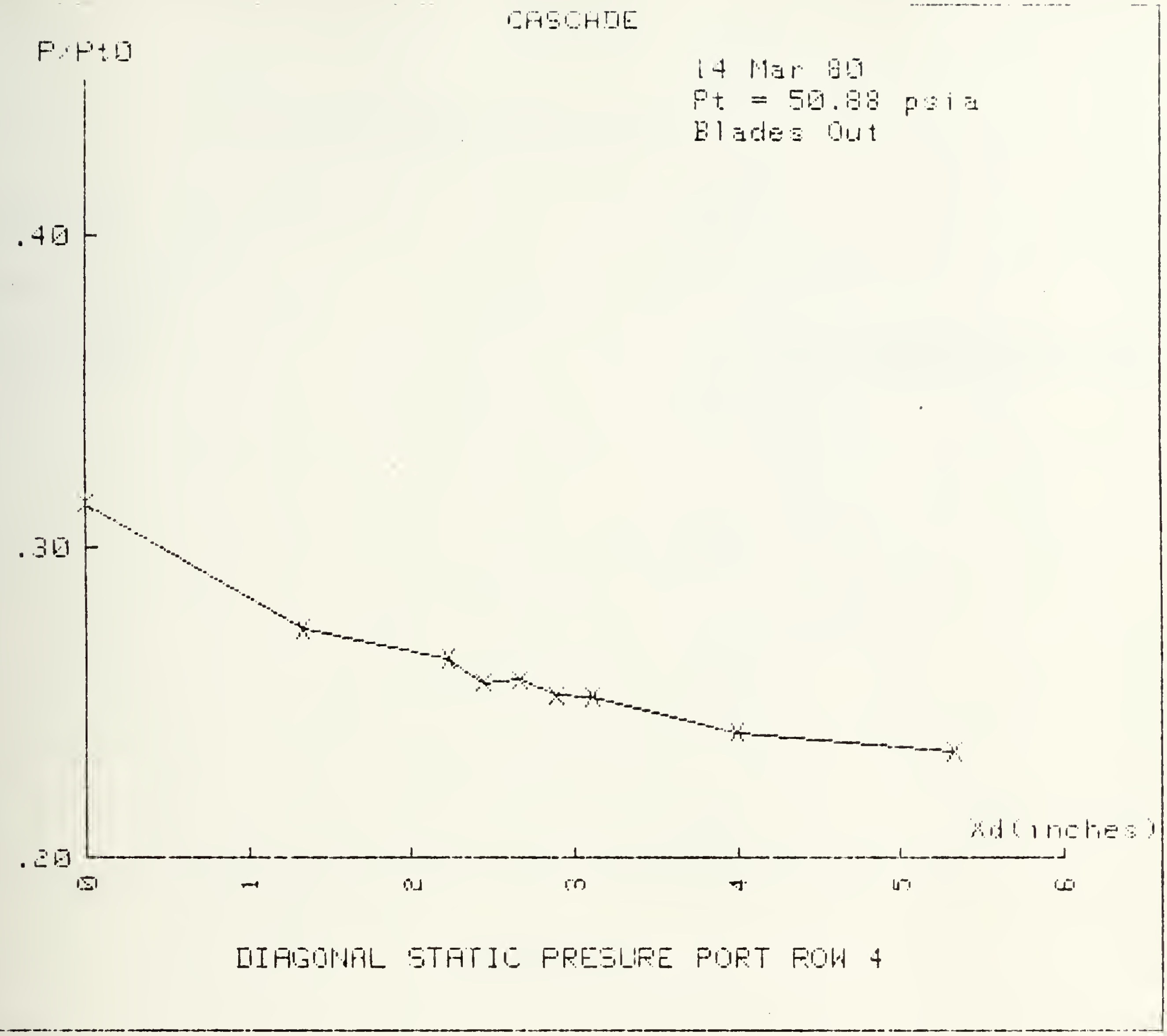


Figure 8e. Pressure Ratio vs. Position (Calibration Test)

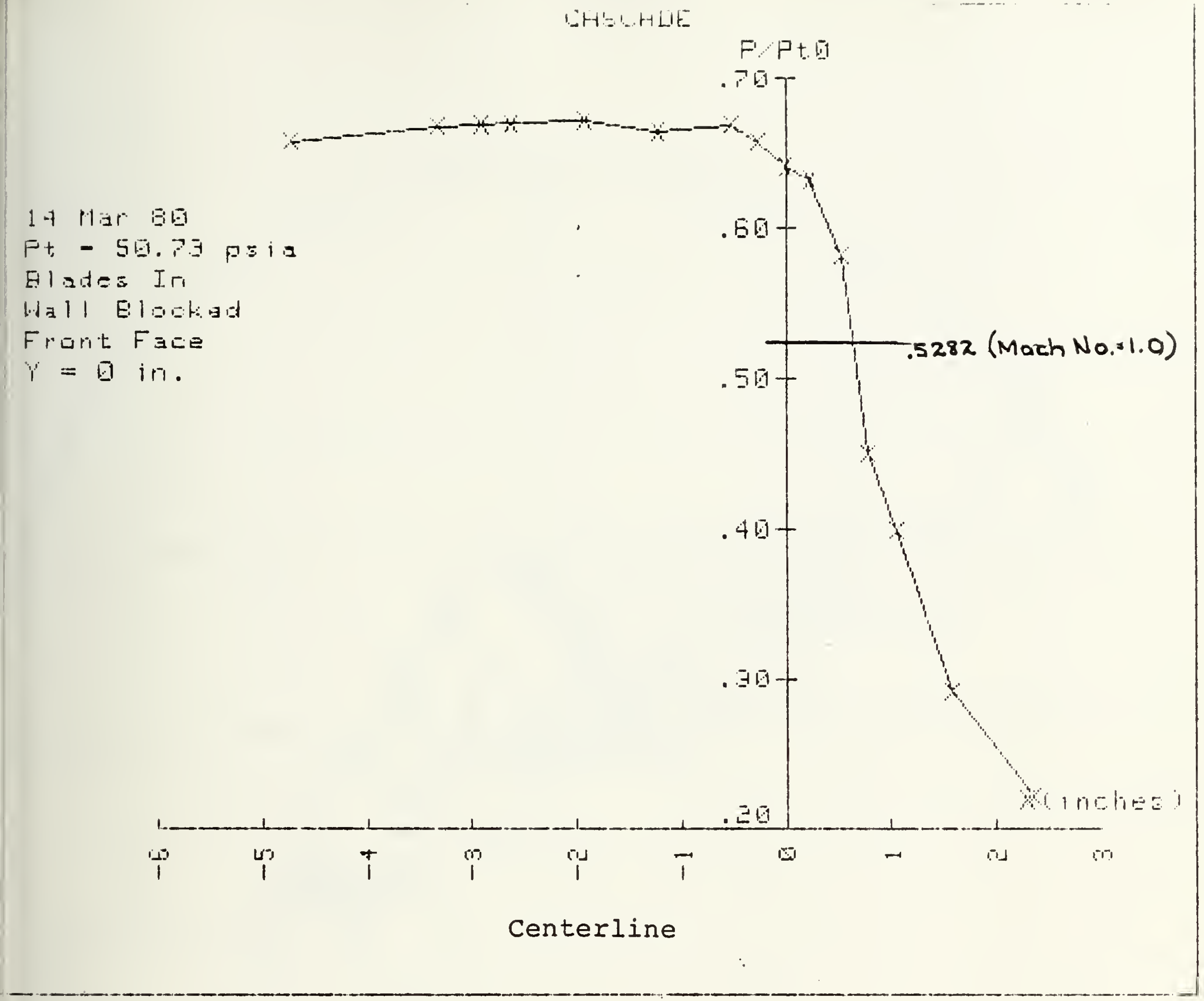


Figure 9. Pressure Ratio vs. Position (Cascade Test I)

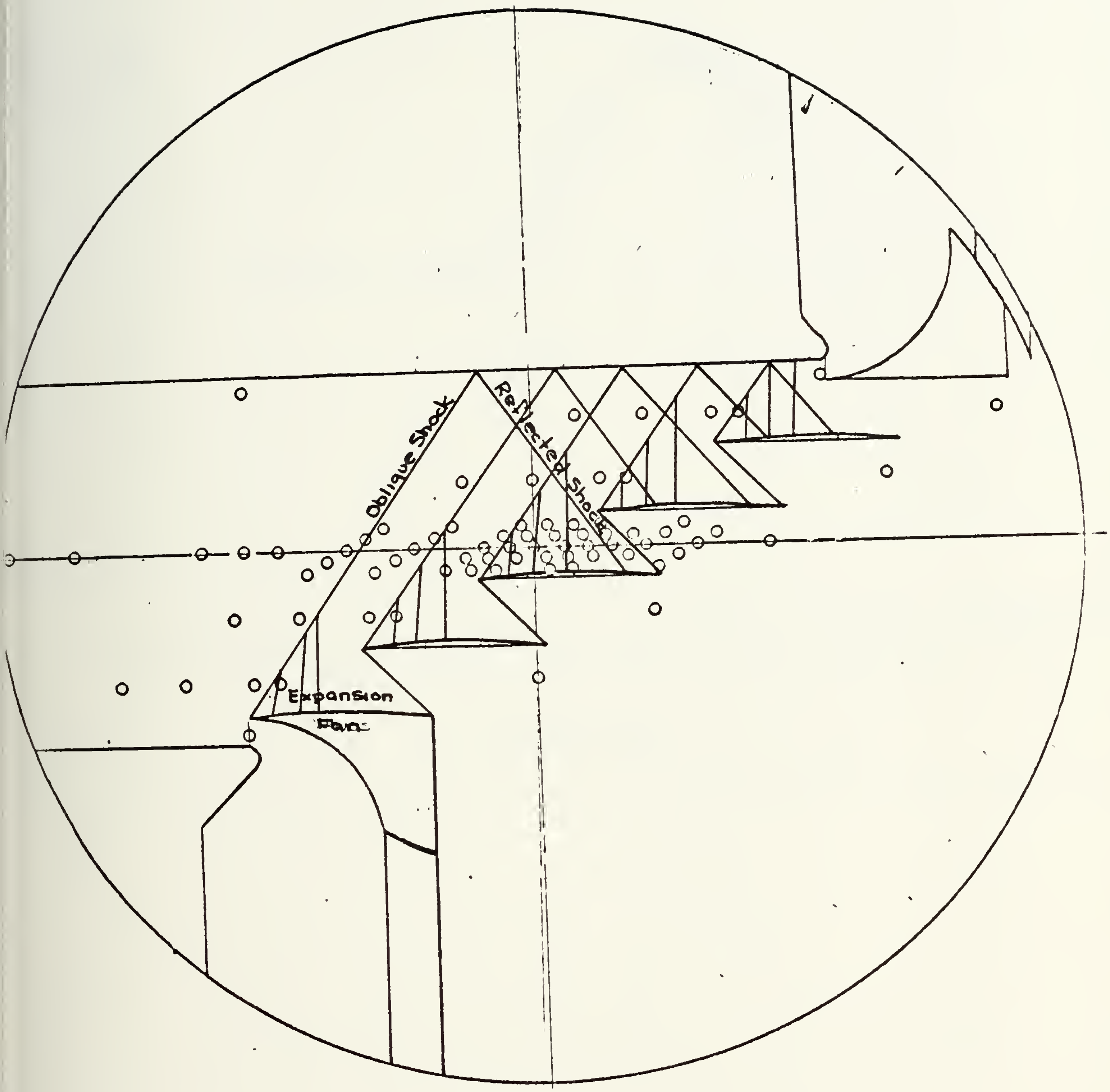


Figure 10. Expected Test Section Wave Pattern (Cascade Tests)

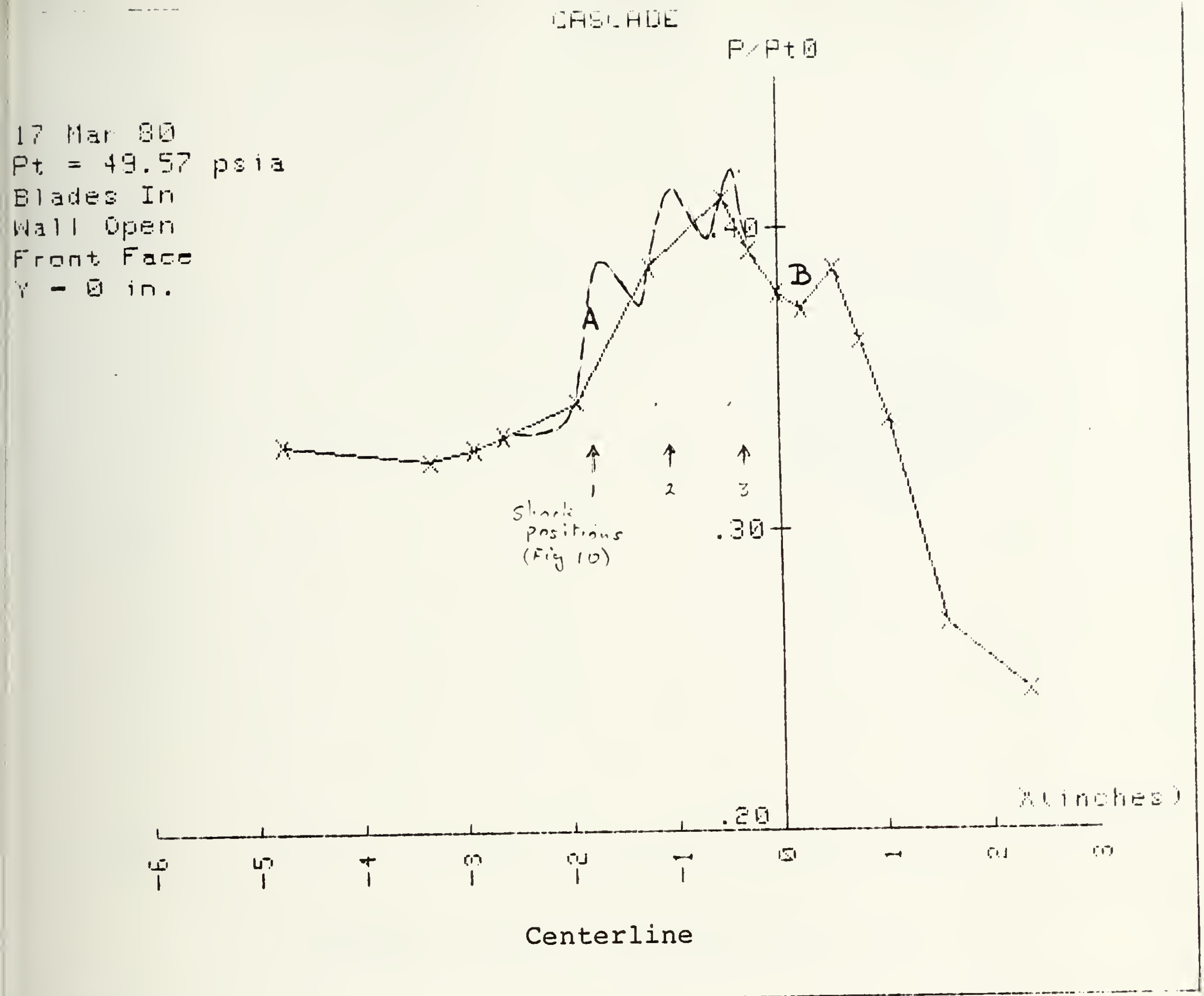


Figure 11a. Pressure Ratio vs. Position (Cascade Test II)

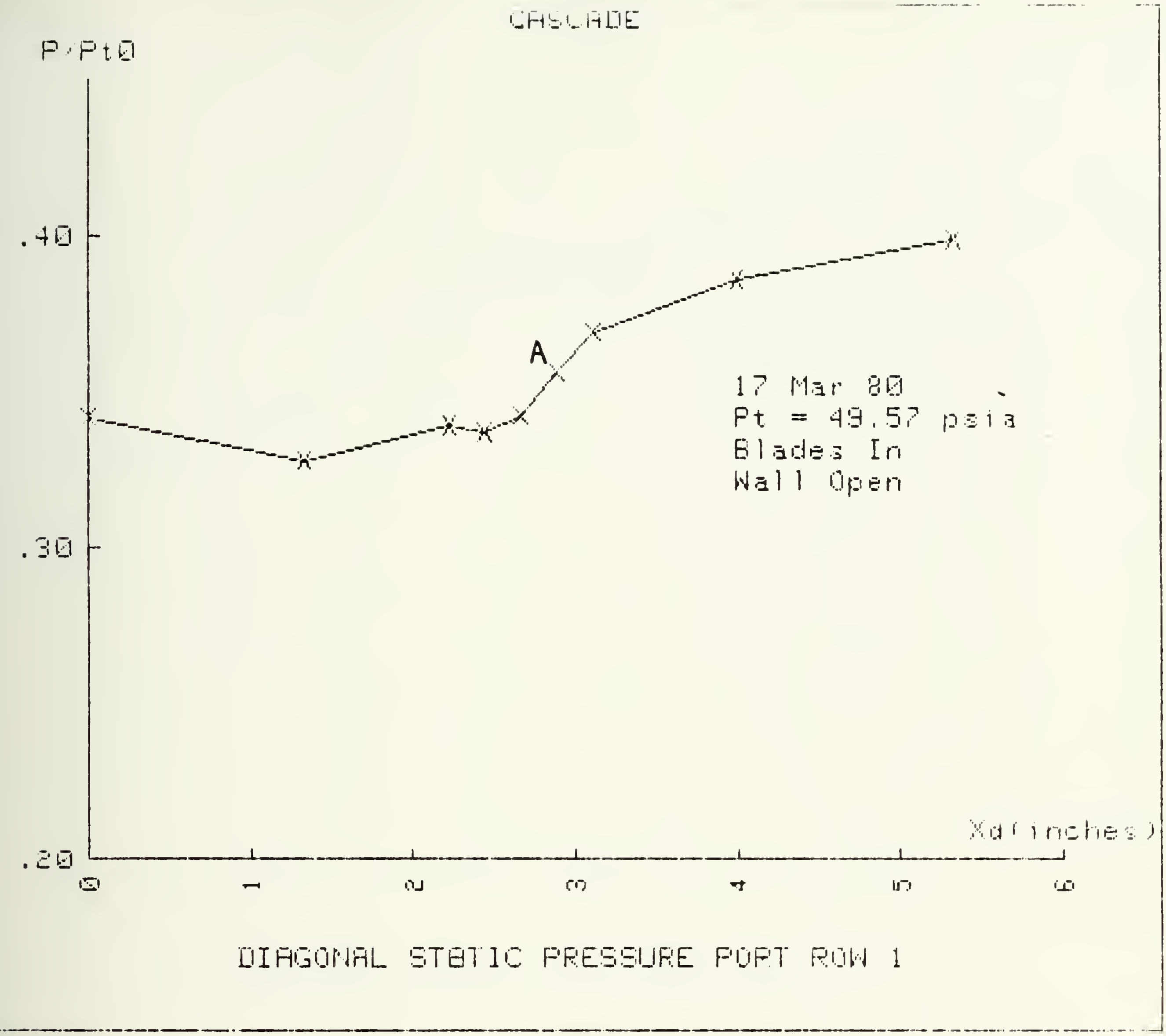


Figure 11b. Pressure Ratio vs. Position (Cascade Test II)

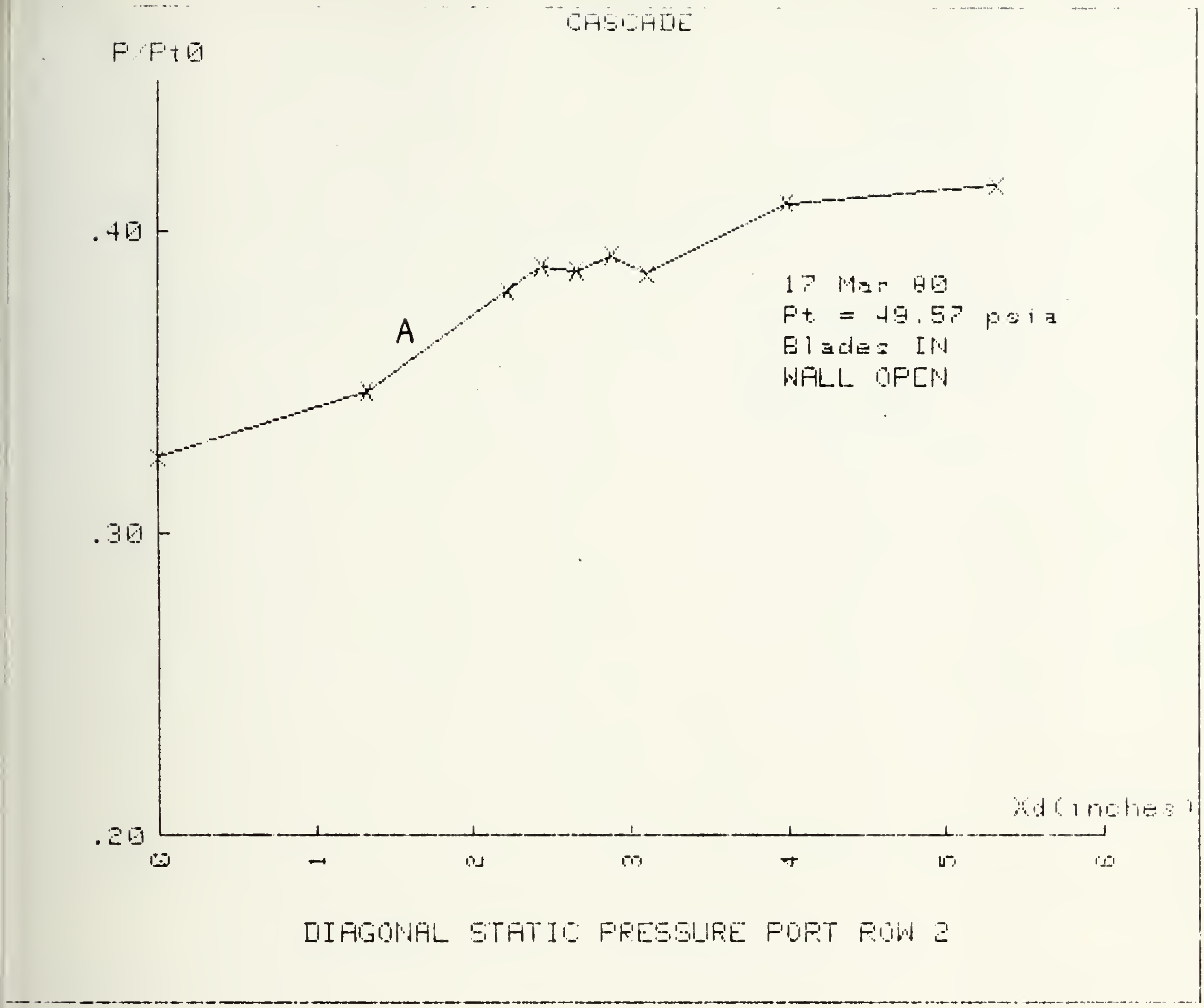


Figure 11c. Pressure Ratio vs. Position (Cascade Test II)

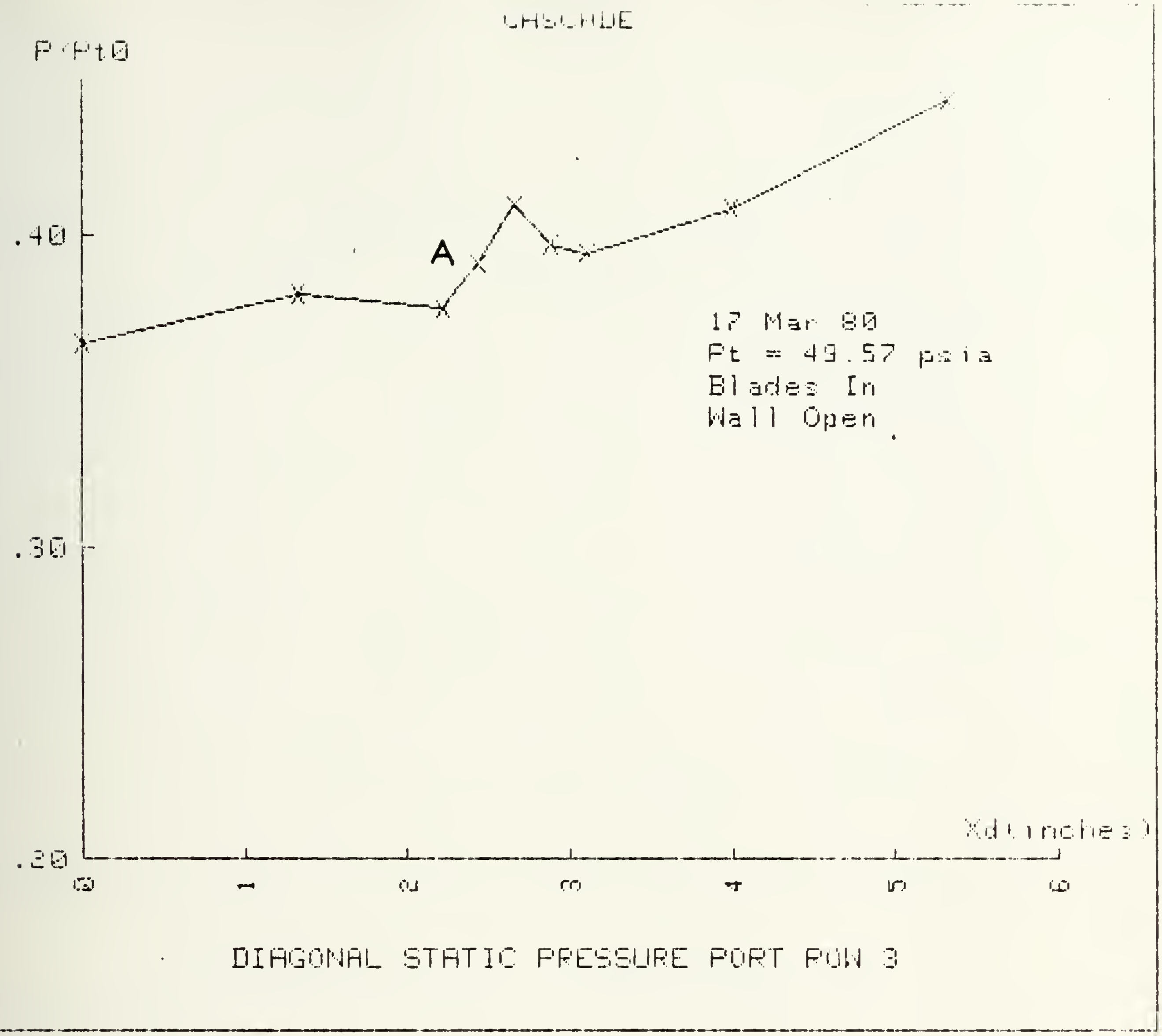


Figure 11d. Pressure Ratio vs. Position (Cascade Test II)

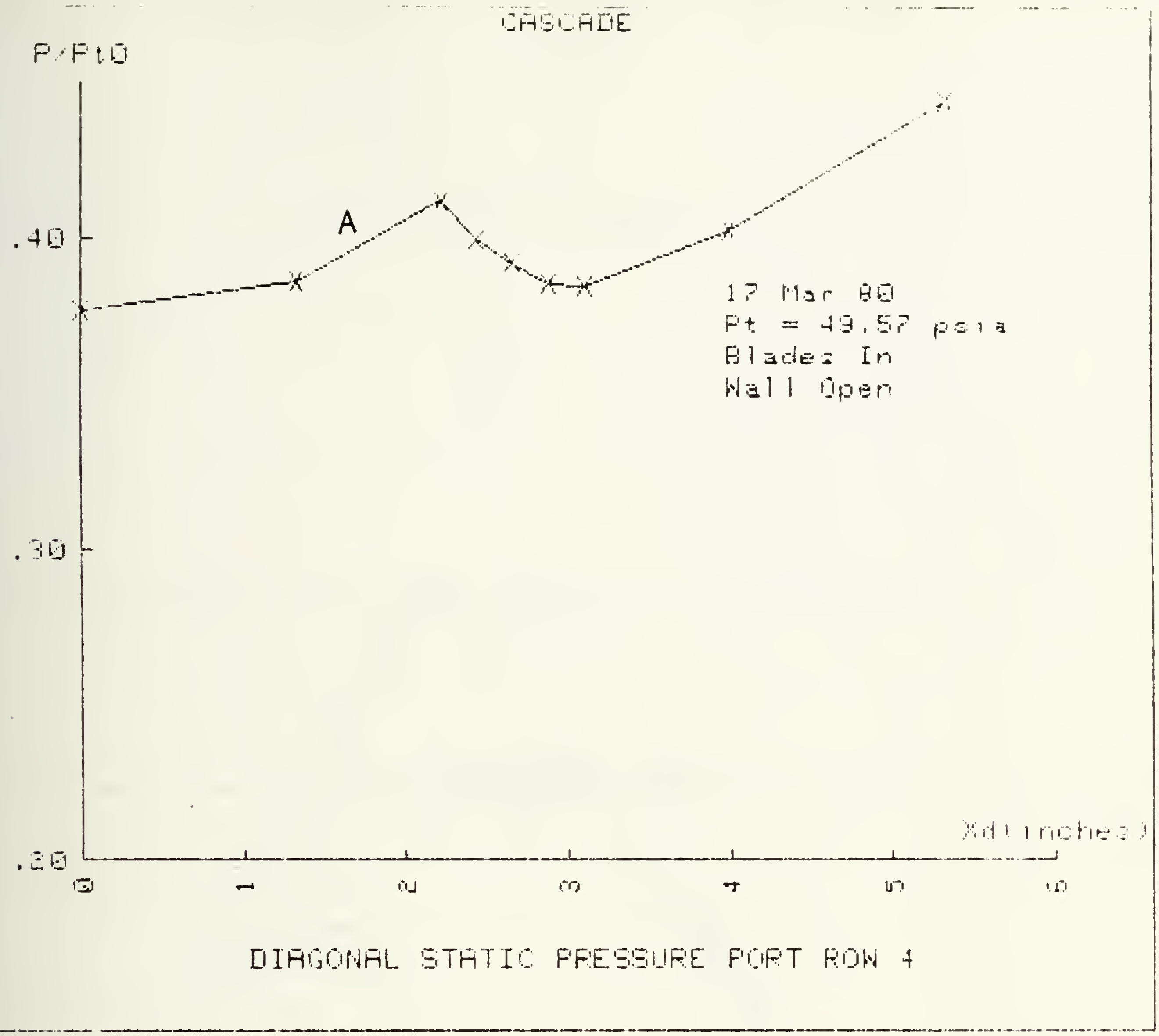


Figure 11e. Pressure Ratio vs. Position (Cascade Test II)

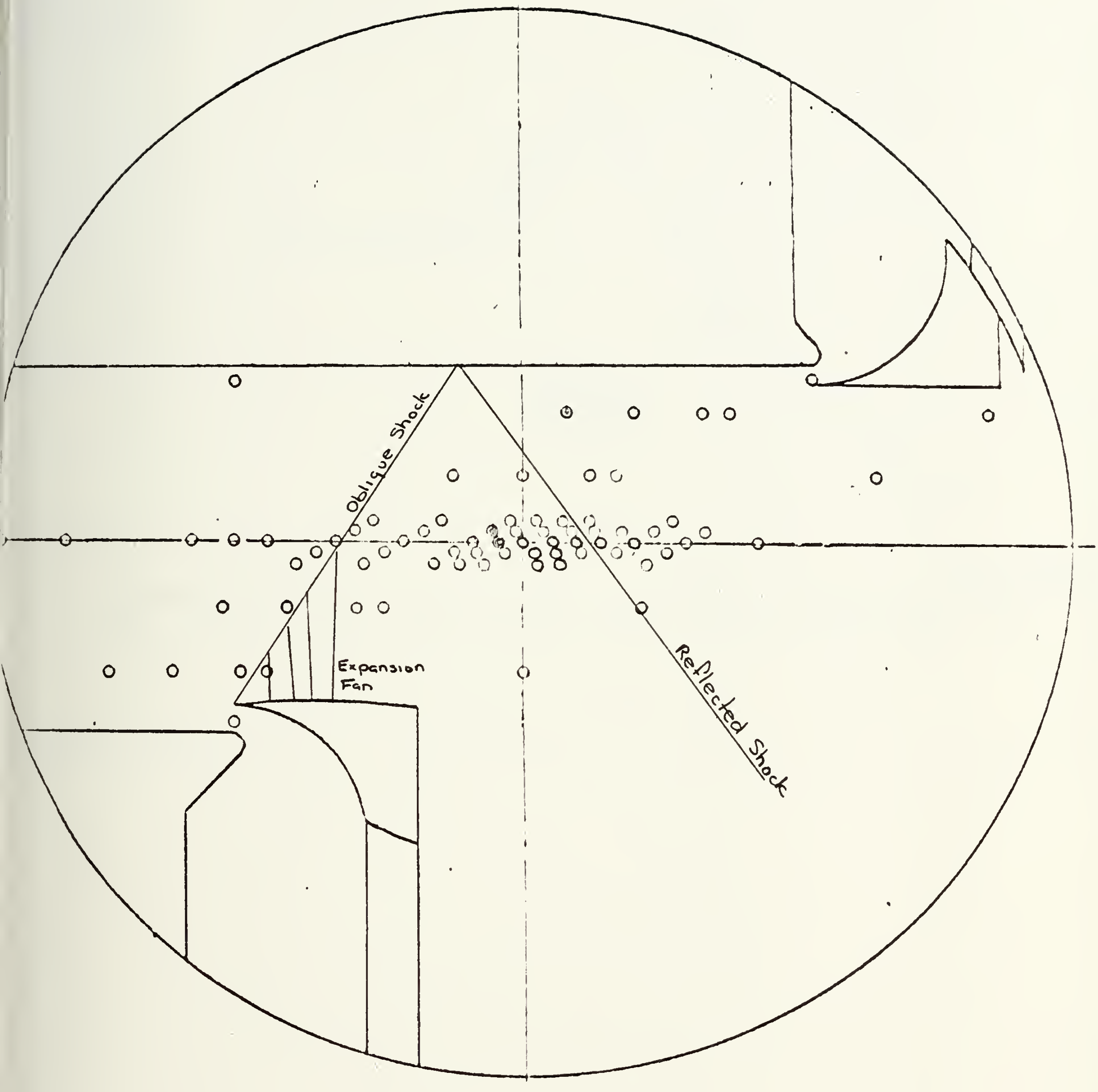


Figure 12. Expected Test Section Wave Pattern (Wave Cancellation Tests)

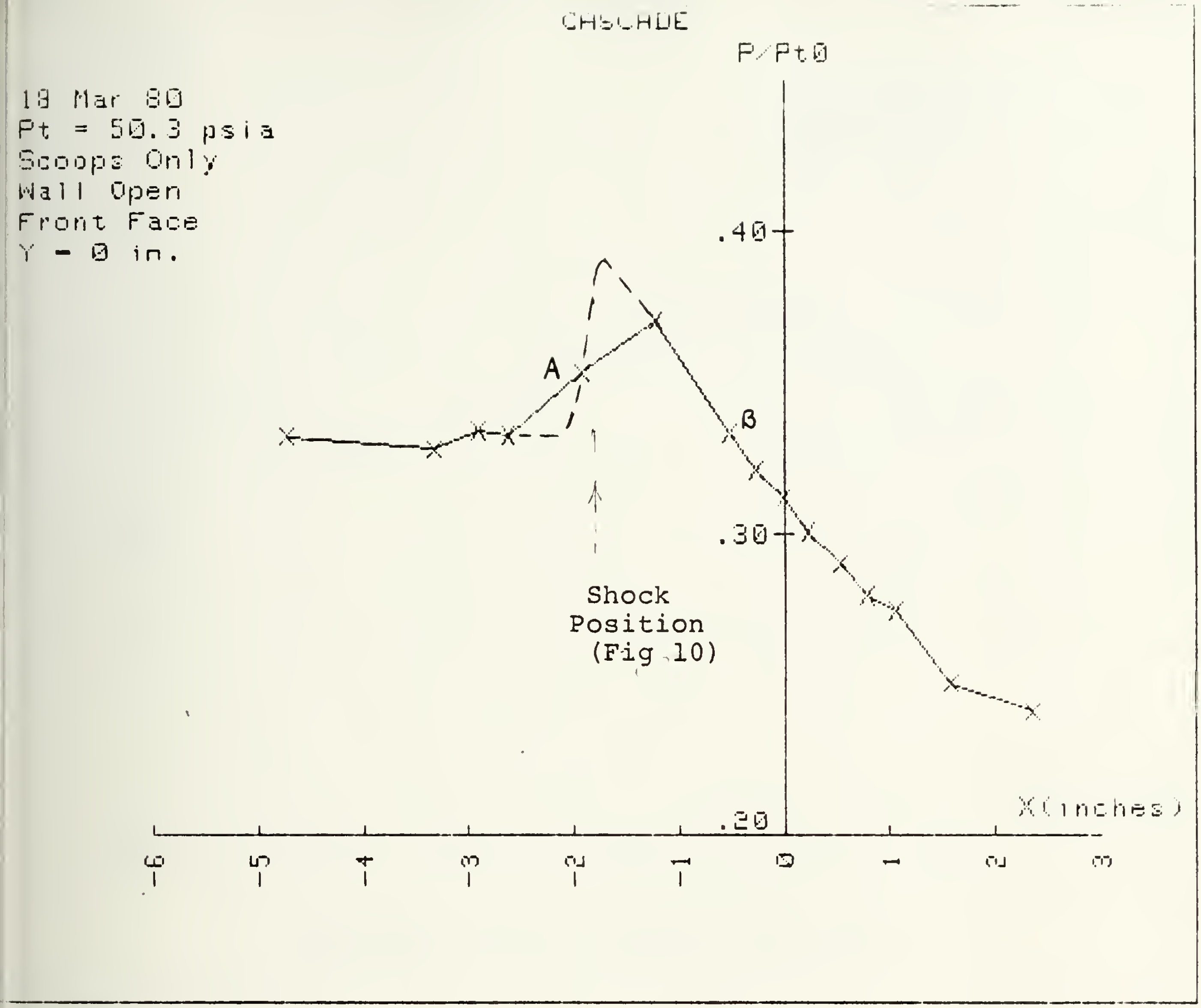


Figure 13a. Pressure Ratio vs. Position (Wave Cancellation Test I)

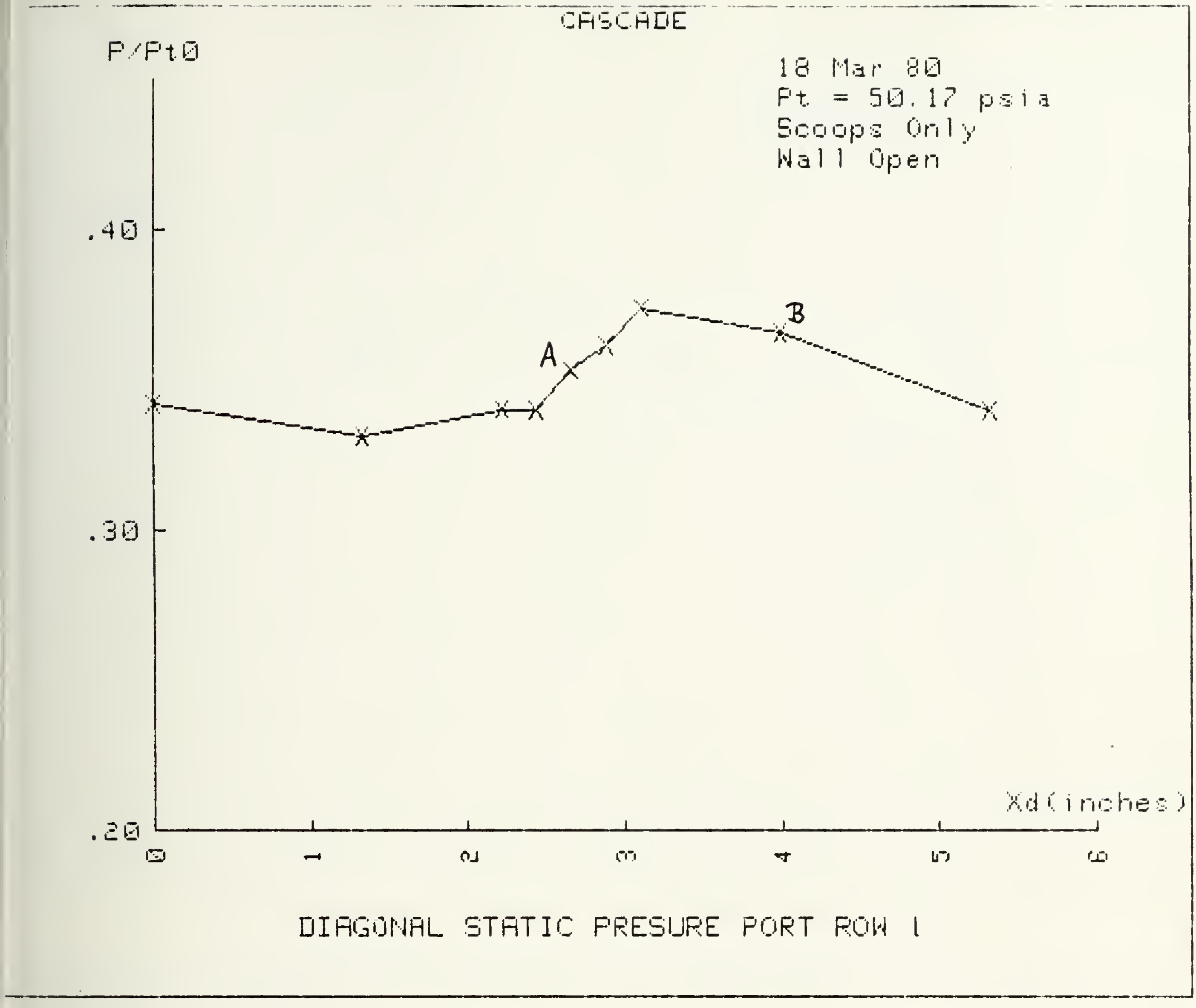


Figure 13b. Pressure Ratio vs. Position (Wave Cancellation Test I)

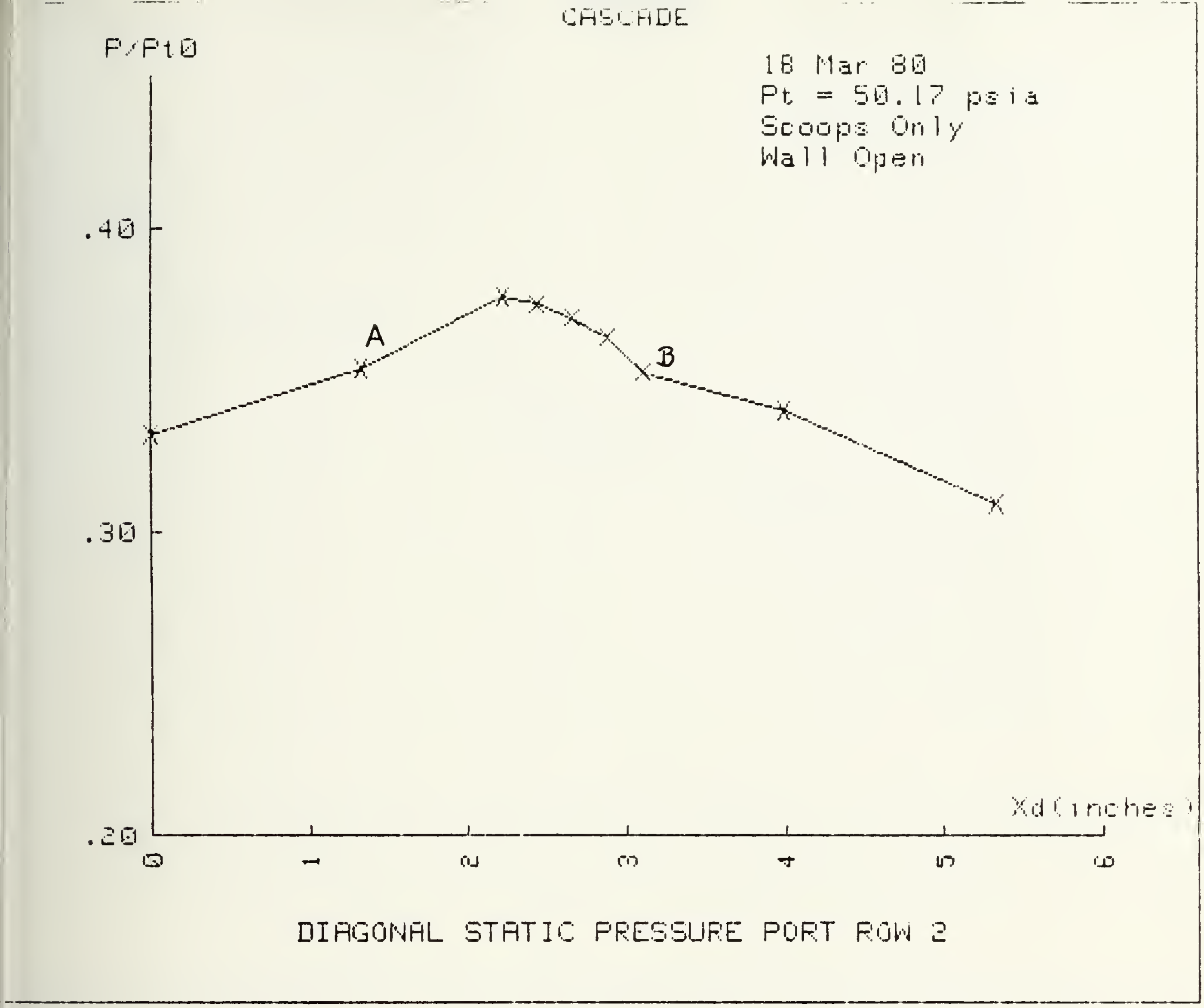


Figure 13c. Pressure Ratio vs. Position (Wave Cancellation Test I)

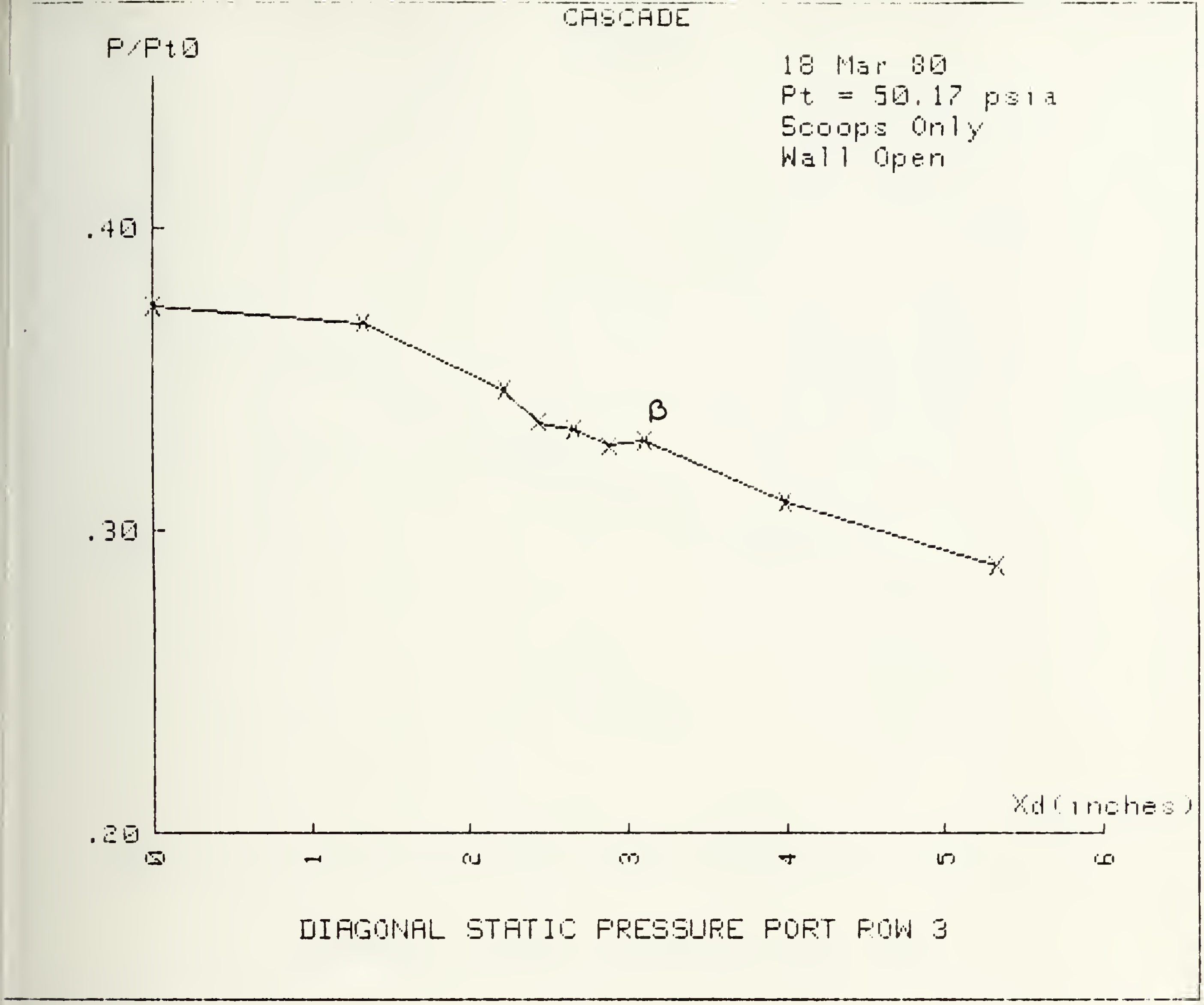


Figure 13d. Pressure Ratio vs. Position (Wave Cancellation Test I)

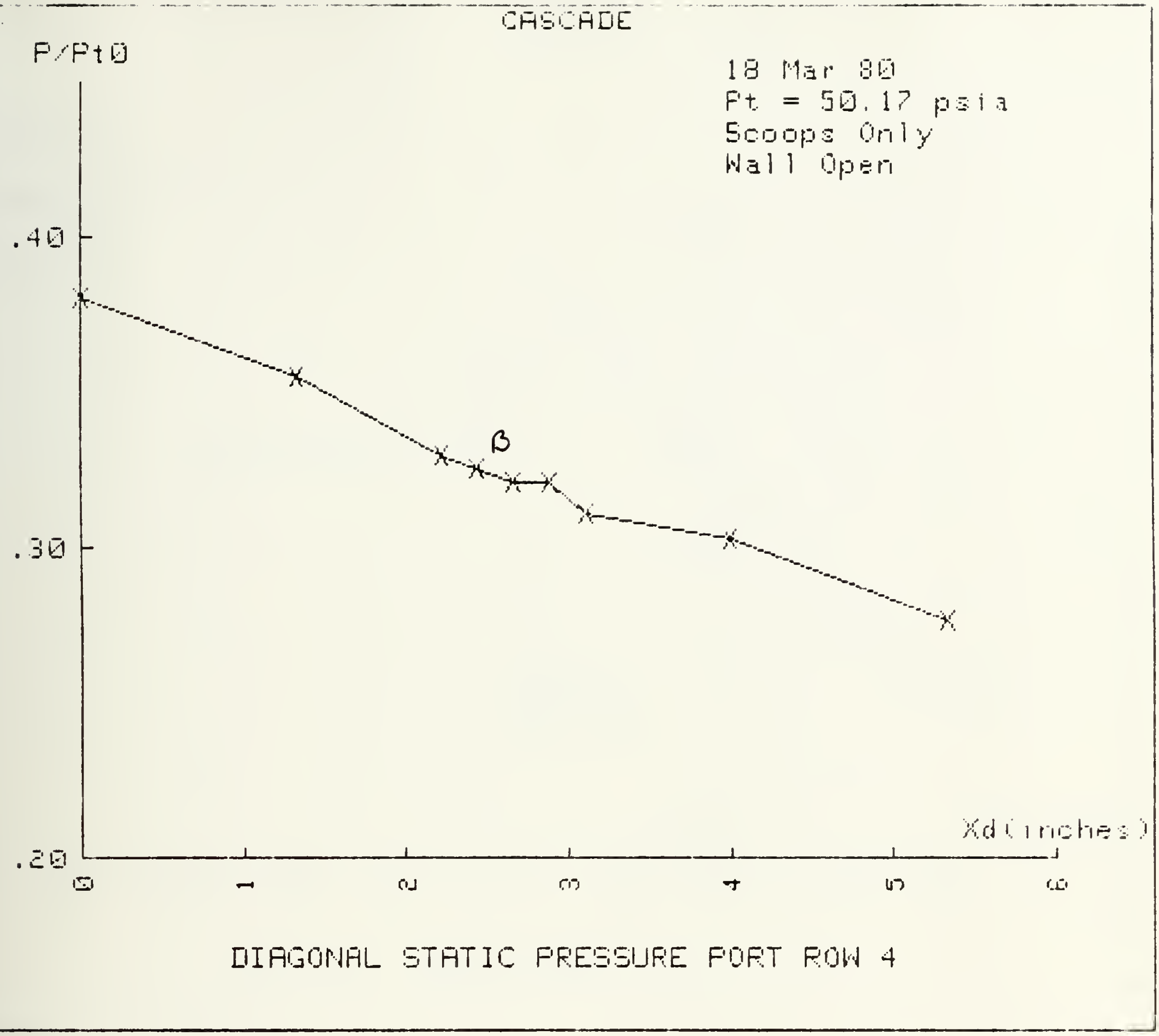


Figure 13e. Pressure Ratio vs. Position (Wave Cancellation Test I)

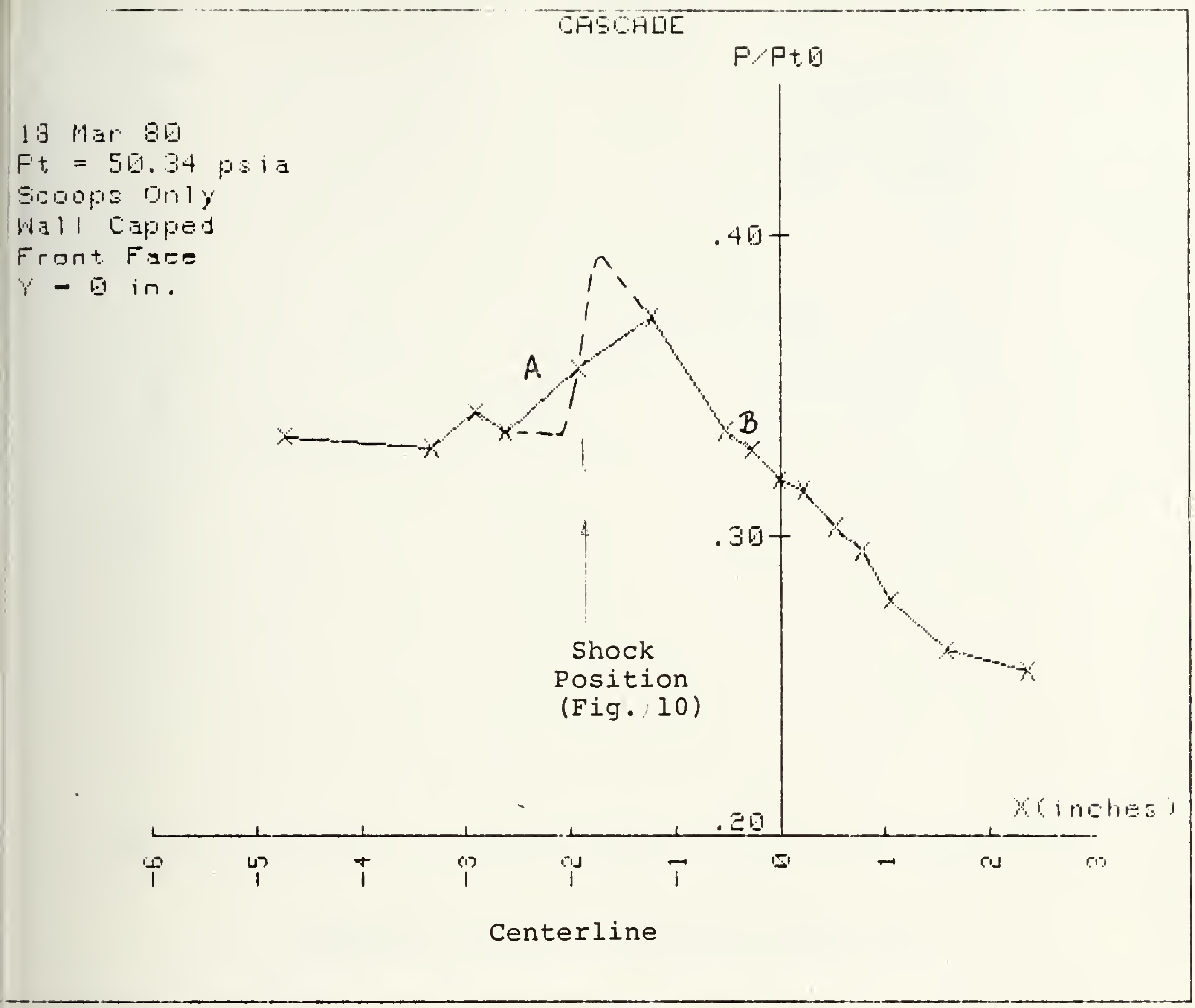


Figure 14a. Pressure Ratio vs. Position (Wave Cancellation Test II)

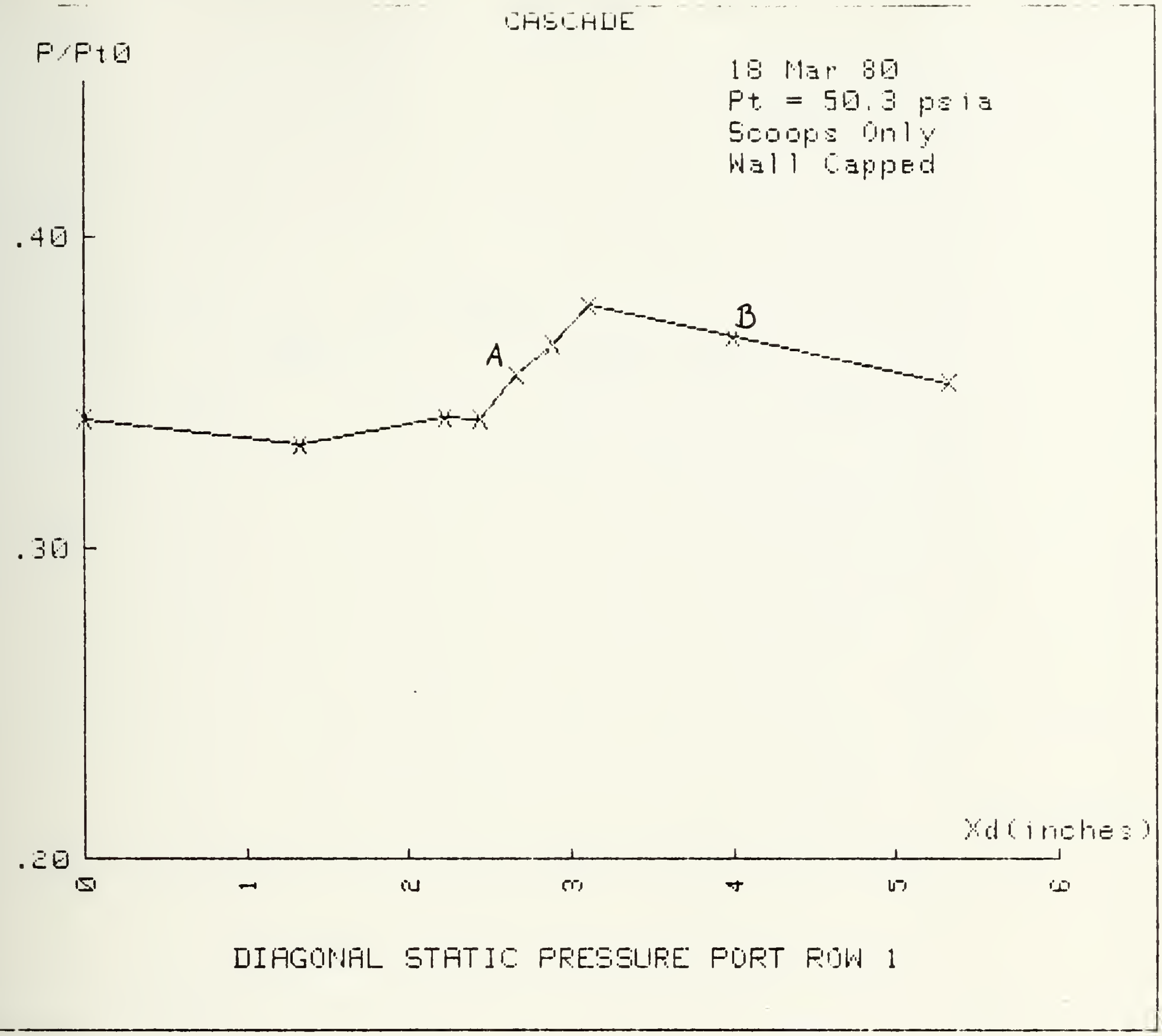


Figure 14b. Pressure Ratio vs. Position (Wave Cancellation Test II)

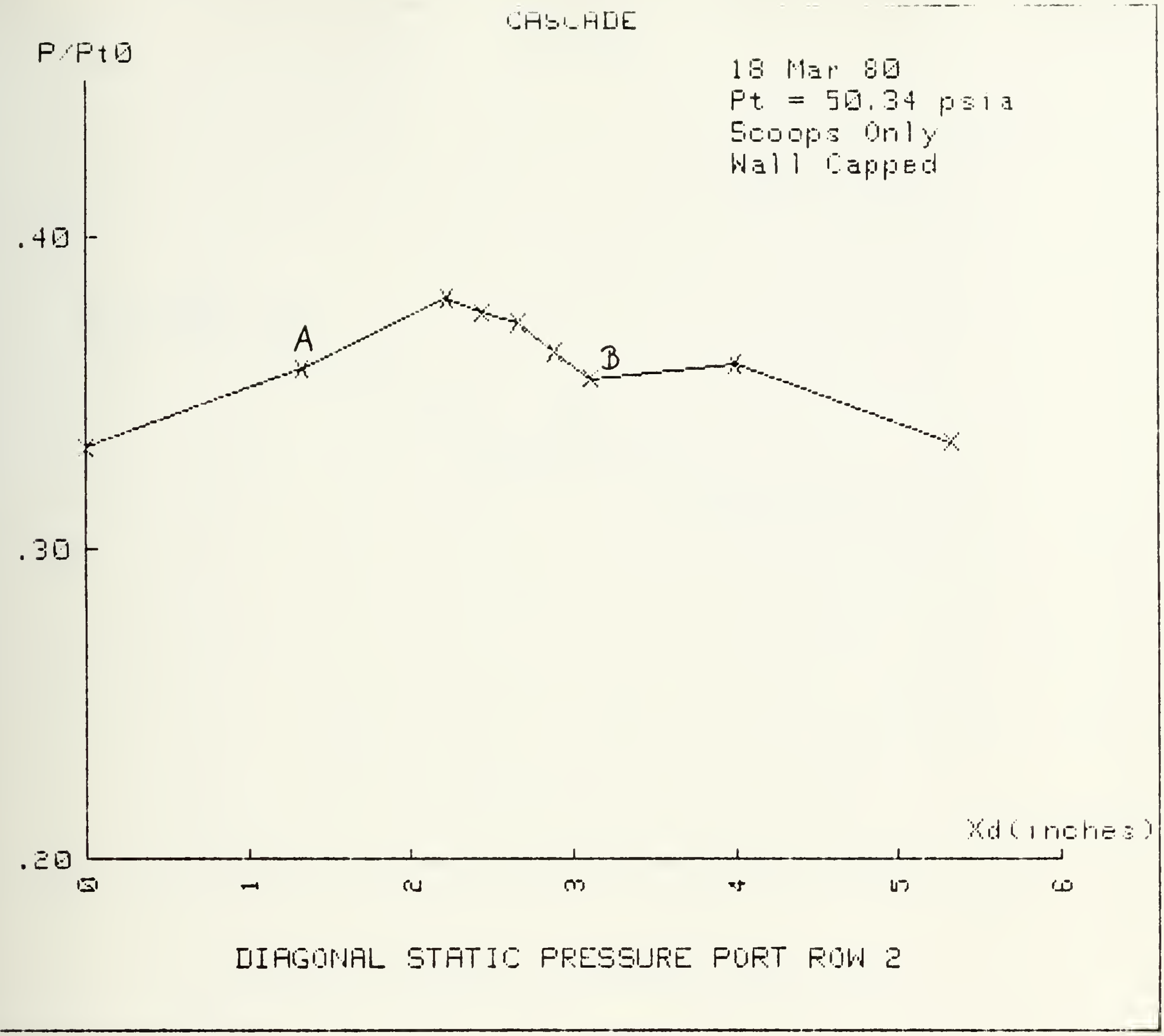


Figure 14c. Pressure Ratio vs. Position (Wave Cancellation Test II)

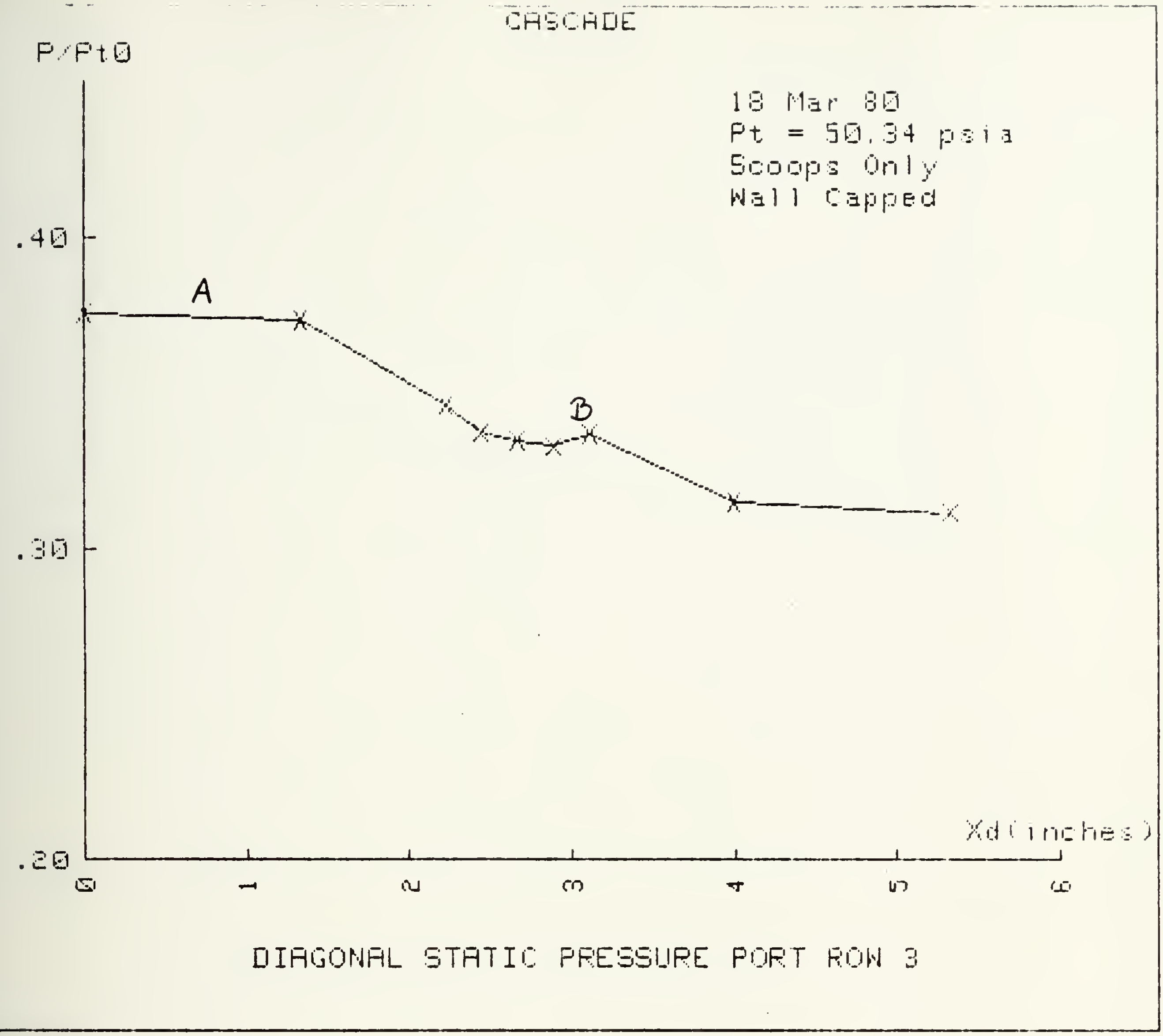


Figure 14d. Pressure Ratio vs. Position (Wave Cancellation Test II)

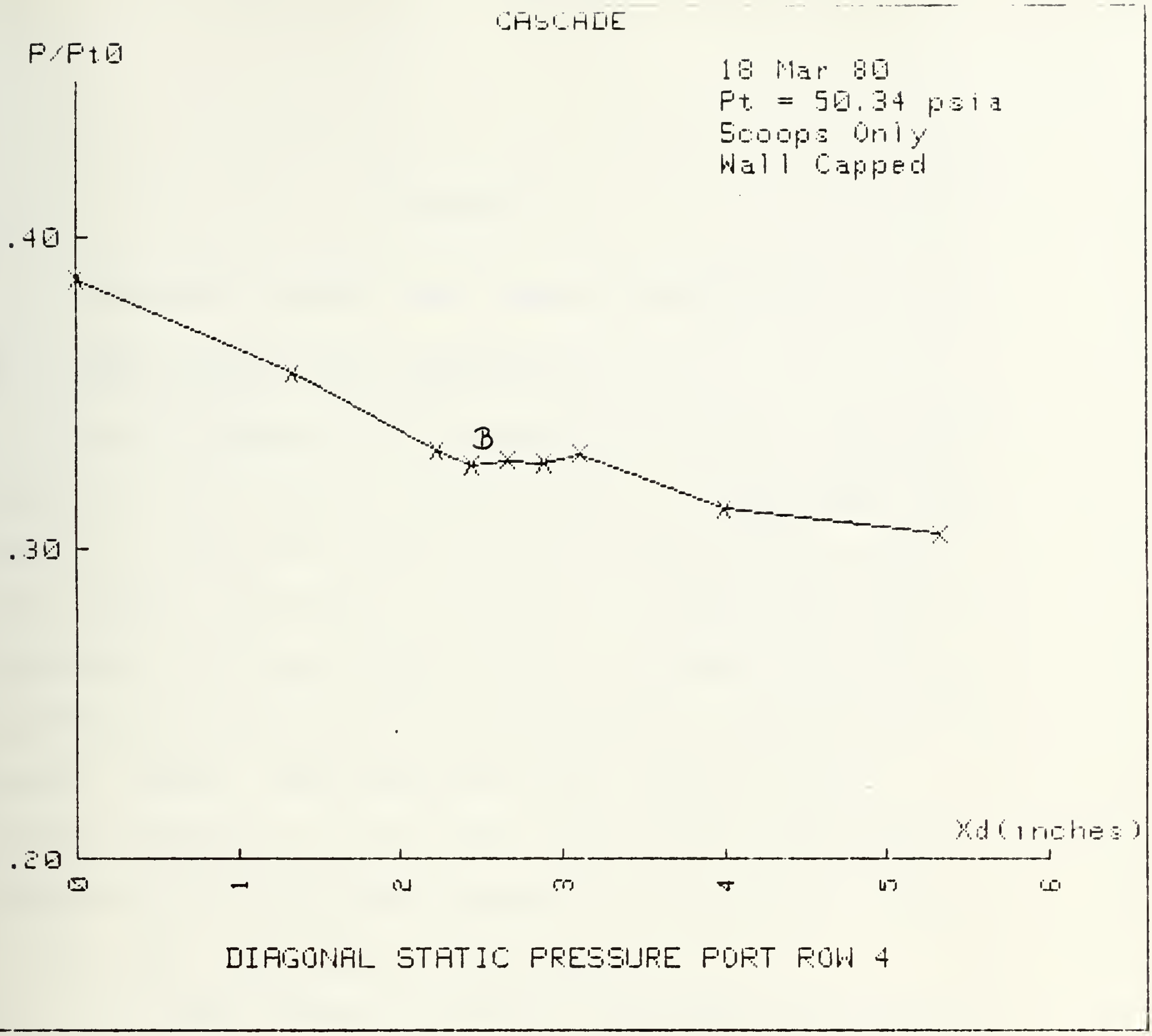


Figure 14a. Pressure Ratio vs. Position (Wave Cancellation Test II)

APPENDIX A

TRANSONIC CASCADE WIND TUNNEL MODIFICATIONS

A1. UPPER NOZZLE BLOCK MODIFICATION

The performance of the cascade wind tunnel would be enhanced in two ways by incorporation of a perforated wall section in the upper nozzle block in the original tunnel test section [Reference 1]. First, a properly designed perforated wall would minimize the reflected disturbances caused by the shock waves generated by the blades and scoops. Second, the perforated wall, due to the air bleeding through it, would also assist in starting the transonic flow through the cascade.

a. Wave Cancellation Principles

In the transonic cascade wind tunnel operating at design conditions of Mach number equal to 1.4 at the nozzle exit, the blades will produce compression and expansion waves which will be reflected at the tunnel boundaries. Solid walls reflect shock waves as compression waves and expansion waves (generated as the flow follows the blade curvature) as expansion waves. An open boundary requires that a condition of constant static pressure be met along the boundary. A compression wave meeting an open boundary reflects as an expansion wave and an expansion wave reflects as a compression wave. The

reflected waves in both the above conditions, in the case of the test cascade, would result in undesirable conditions that are not representative of the flow in an operating compressor. Since the open and solid boundaries produce wave reflections having opposite characteristics there is a possibility of eliminating the reflections by the proper mixture of open and solid boundaries. The ideal condition for shock wave cancellation would exist if the inclined flow behind the oblique shock produced a pressure drop as it flowed through the wall equal to the pressure rise through the incident oblique shock wave. This would result in equilibrium between the static pressure in the flow and in the plenum and no reflection would occur. Linearized theory of wave cancellation in perforated wind tunnels [Reference 5], resulted in the following equation for the open area ratio, R, , for no reflection.

$$\frac{\Delta p}{q} = \frac{2}{(M^2 - 1)^{\frac{1}{2}}}\left(\frac{1}{R} - 1\right)\theta = K\theta$$

This equation implied that the required open area ratio is independent of Mach number and shock intensity and for the present case would be have a value of $R = 0.5$.

In actuality the flow is not isentropic and does not follow linearized Prandtl-Glauert theory and in the transonic Mach number range the perforated wall open area ratio required for wave cancellation is significantly reduced from that predicted by linearized theory.

b. Perforated Plate Design

The design of the perforated plate required that the following parameters be considered; plate size, hole size, hole inclination, open area ratio, plate thickness and hole pattern.

(1) The size of the section of the upper nozzle block to be replaced by the perforated plate was determined by the expected shock wave pattern caused by the blades and scoops at design operating conditions. The shock wave pattern was determined over the full range of blade incidence angle available ($\pm$ 3 deg) in the cascade. The plate was designed to insure that the forward-most shock would impinge on the plate downstream of the first row of perforations.

(2) The determination of the hole size, that is, the diameter measured perpendicular to the axis of the hole, was based on two criteria. Experimental results presented in Reference 6 indicated that the hole diameter was optimized when it was approximately 1/80 of the tunnel height. These

experiments also determined that the displacement thickness of the boundary layer should not exceed 15 per cent of the hole diameter in order to avoid irregularities in the flow over the perforated plate.

(3) The determination of the best inclination of the holes for the present cascade wind tunnel was based on linearized theory and experimental results as presented in References 5 and 6. Holes inclined in the direction of flow drastically reduced out-flow resistance and increased inflow resistance (Figure A.1). The inclined holes also resulted in characteristic curves of wall pressure differential vs. mass flow ratio having significantly steeper slopes at small and negative flow ratios. Using inclined holes avoided the irregular characteristic produced by straight holes.

(4) Experimental results reported in References 5 and 6 were used in selecting the proper open area ratio for the perforated wall section.

Experiments indicated that the open ratio required for wave cancellation with inclined holes was approximately 25 percent of that required for normal holes. The requirement for fewer holes greatly eased the problem of fabricating the perforated plate and reduced the risk of structural weakness.

(5) When the above plate design parameters were selected the plate thickness was considered. The effectiveness of the inclined hole configuration to guide inflow against test section flow requires that the lengths of the inclined holes are sufficient to produce this counter flow effect. Experimental data [Reference 5] indicated consistent, nearly linear characteristics when the hole diameter was between the plate thickness and twice the plate thickness. A plate thickness very nearly equal to the hole diameter was selected to insure the maximum plate bending strength without degrading the design with respect to wave cancellation.

(6) The perforation pattern was selected to give an even hole distribution over the

entire width of the upper nozzle block in the area covered by the perforated plate. The hole stagger angle, hole-to-hole and row-to-row separations were calculated to insure that the plenum plate support ribs would not be restrictive.

Data resulting from the design of the perforated plate are given in Table A-1 and the machine drawing of the plate is given in Figure A2.

Table A-1. Perforated Plate Characteristics

Open Area Ratio (R)	6%
Plate Thickness	0.040
Hole Diameter, in. (perpendicular to hole axis)	0.047
Hole Inclination	60 deg
Plate length, in	4.375
Plate width, in	1.880
Hole Stagger Angle	15.16 deg
Hole-to-Hole Separation (in rows), in	0.167
Row Separation, in	0.167
Material	7075-T6 Aluminum

c. Perforated Wall Plenum Design

The perforated wall plenum was designed to provide an evenly distributed pressure on the plenum side and to provide the required structural support for the perforated wall. The even pressure distribution on the plenum side of the wall was essential to create an even mass outflow over the entire perforated plate area.

The design required that when the plate was installed the dimensions of the upper nozzle block matched those of the original design [Reference 1] under all anticipated tunnel operating conditions. The plenum ribbed mounting structure was designed so that the stresses in the plate did not exceed the tensile strength or cause a bending deflection greater than 0.0005 inches with a pressure differential of 3 atmospheres across the plate. The stress (S) and deflection (W) were determined in accordance with Reference 7 using the equations:

$$S_m = \beta \frac{qa^2}{t^2}$$

$$W_m = a \frac{qa^2}{Et^3}$$

Since it was difficult to predict accurately the degree of weakening of the plate caused by the perforations, the worst case conditions were used. The stress coefficient (β) was taken for the case where all the edges of the plate

sections analyzed were clamped, and the deflection coefficient, (a), was taken for the case where the section analyzed had all edges pinned.

The plenum exit was sized so that at the anticipated wall mass flow rate of less than 0.4 percent of the tunnel mass flow [Reference 5], by continuity, the exit velocity would be approximately 50 ft/sec.

The "O" ring on the upper nozzle block was rerouted around the perforated wall plenum. The machine drawing for the upper nozzle block modification is given in Figure A3.

d. Final Assembly

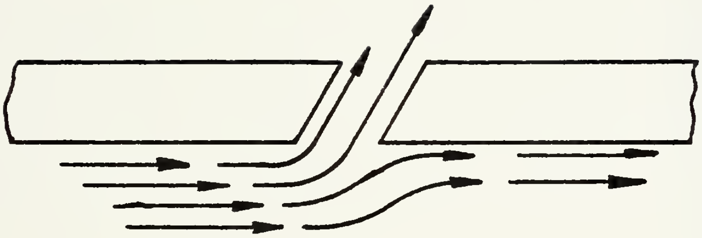
Views of the nozzle modification are given in Figure A4. The perforated plate was attached to the modified upper nozzle block with two screws on each end of the plate and Conley Weld Epoxy along the edges of the mounting ribs. The reassembled nozzle was reinstalled in the cascade wind tunnel.

A.2. BLADE AND MOUNTING PINS MODIFICATION

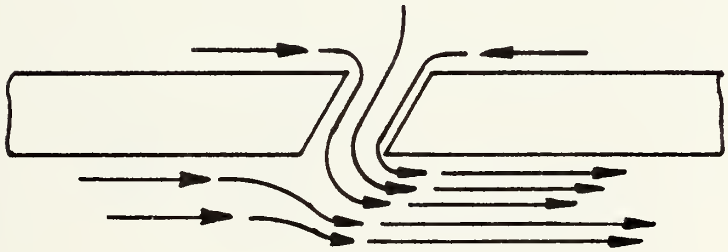
Revised [from Reference 1] machine drawings for the cascade blades and blade mounts are given in Figure A5. The revisions were required in order to show required blade dimension tolerances and surface smoothness, and to change the blade mounting pin design to make assembly easier. Cascade blade data are presented in Table A-2. The blades were manufactured by Experimental Engineering, Inc. of Irvine, California.

Table A-2 Cascade Blade Data

Scale Factor (z)	0.7
Stagger Angle (γ)	59 deg, 44 min, 35 sec
Camber Angle (ϕ)	4.7 deg
Blade Spacing (s), in	1.344
Blade Chord (c), in	1.822
Leading Edge and Trailing Edge Radii, in	.007
Suction Side Radius, in	11.431
Maximum Thickness, in	.045



Flow Out of Test Section



Flow Into Test Section

Figure A.1 Streamline Pattern for Inflow and Outflow Through a Wall with Inclined Holes

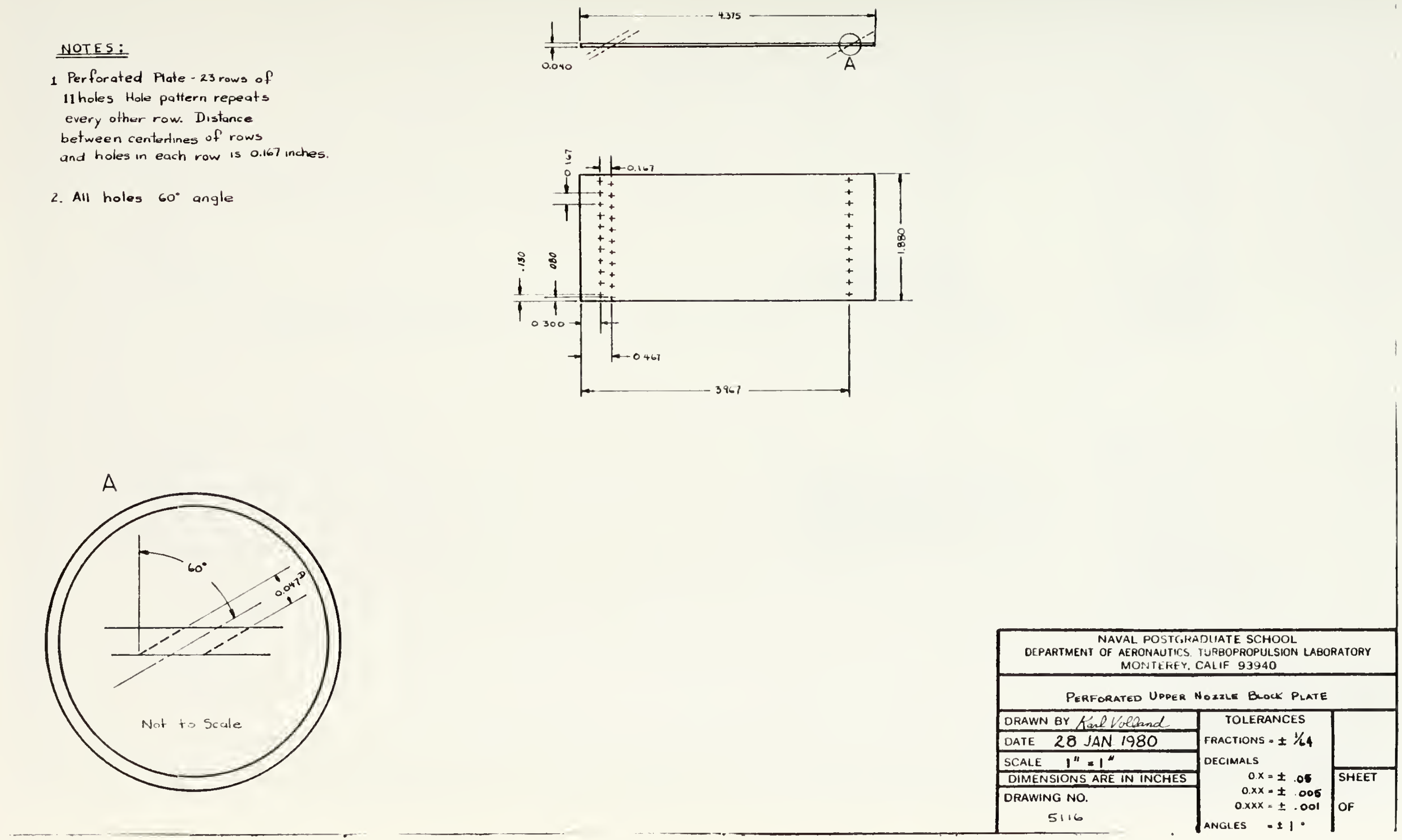


Figure A2 Perforated Plate Machine Drawing

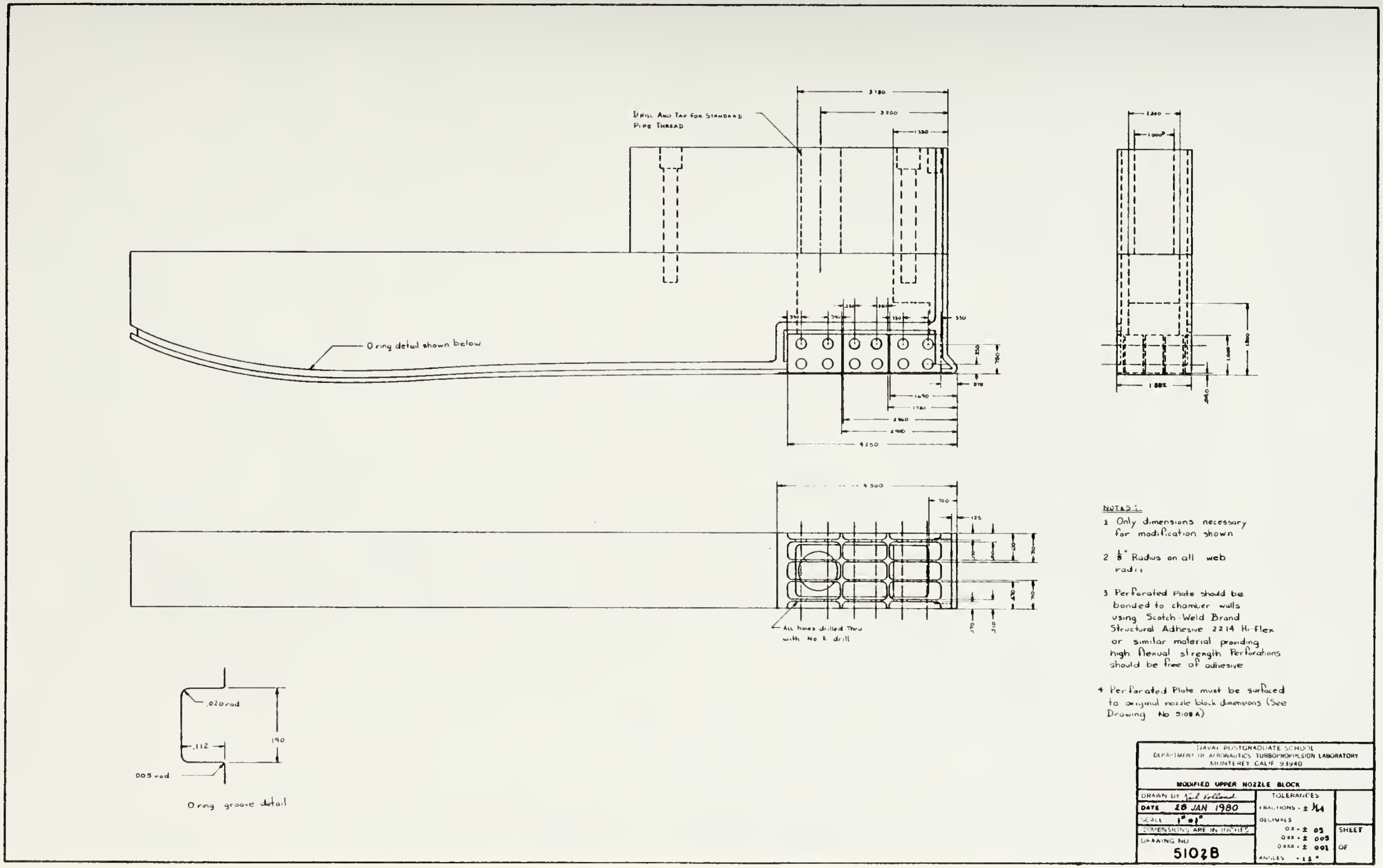


Figure A3 Modified Upper Nozzle Block Machine Drawing

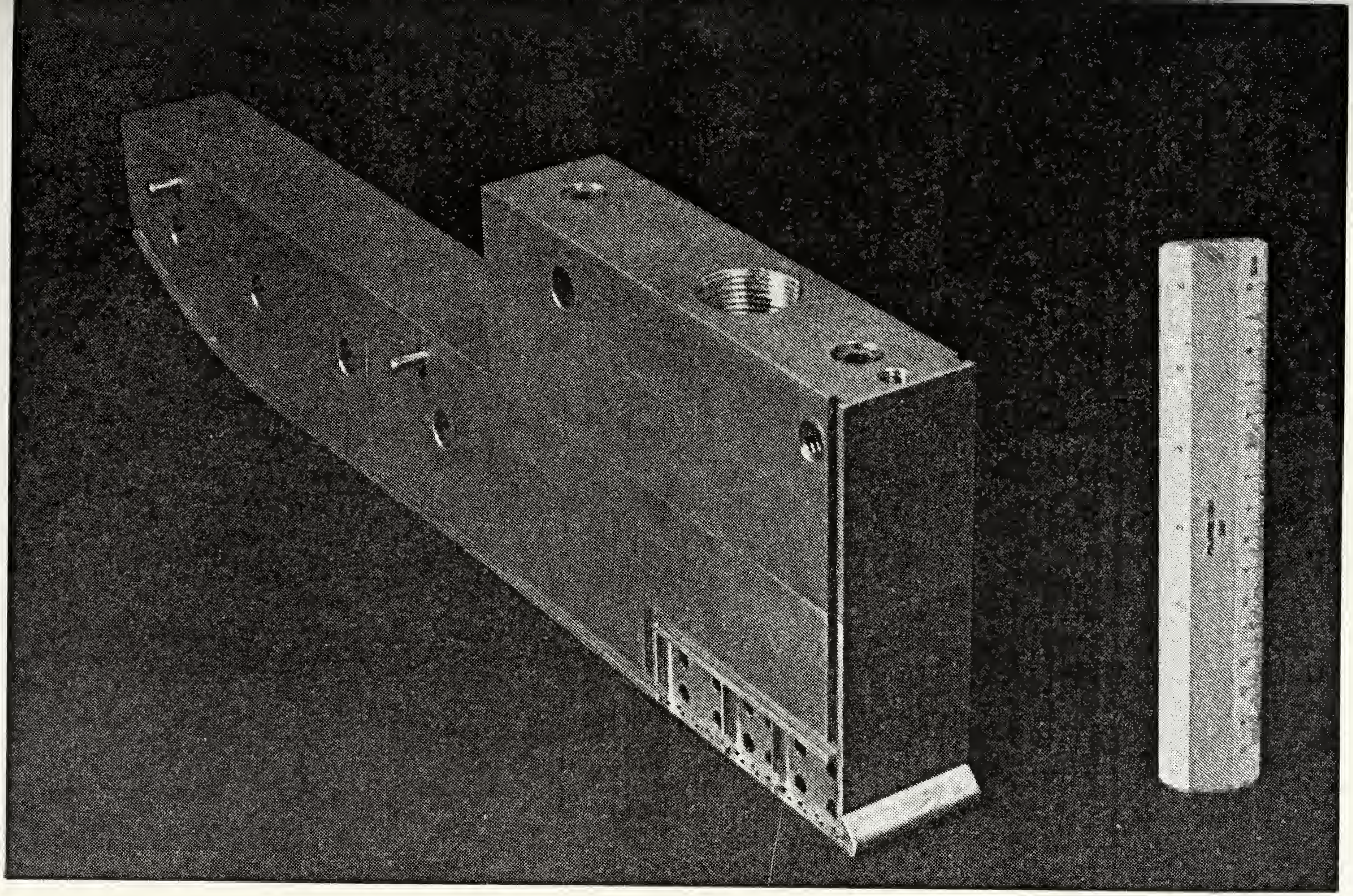


Figure A.4a Assembled Upper Nozzle Block Modification
Top-rear Three Quarter View

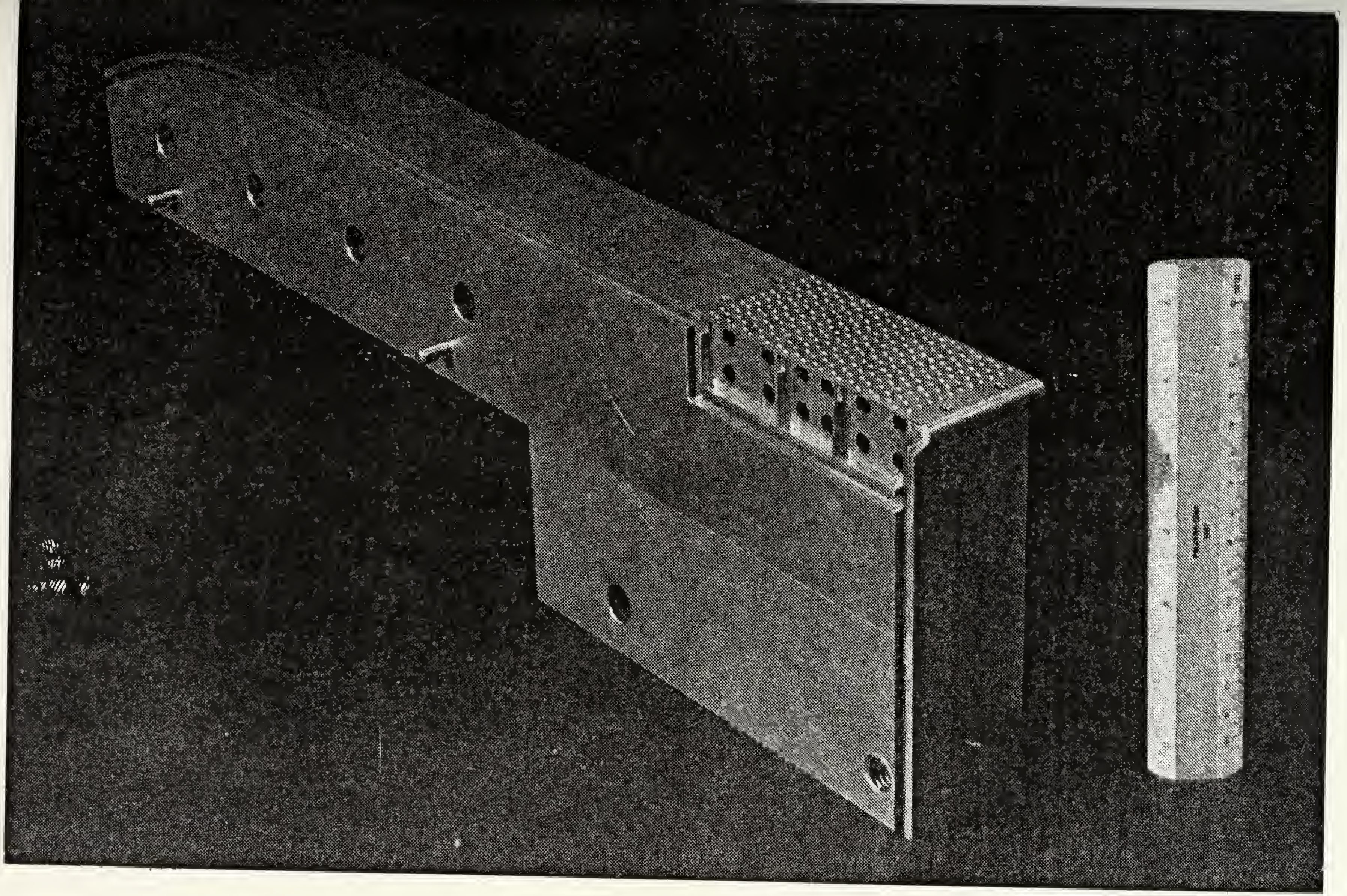


Figure A.4b Assembled Upper Nozzle Block Modification
Botton-rear Three-Quarter View

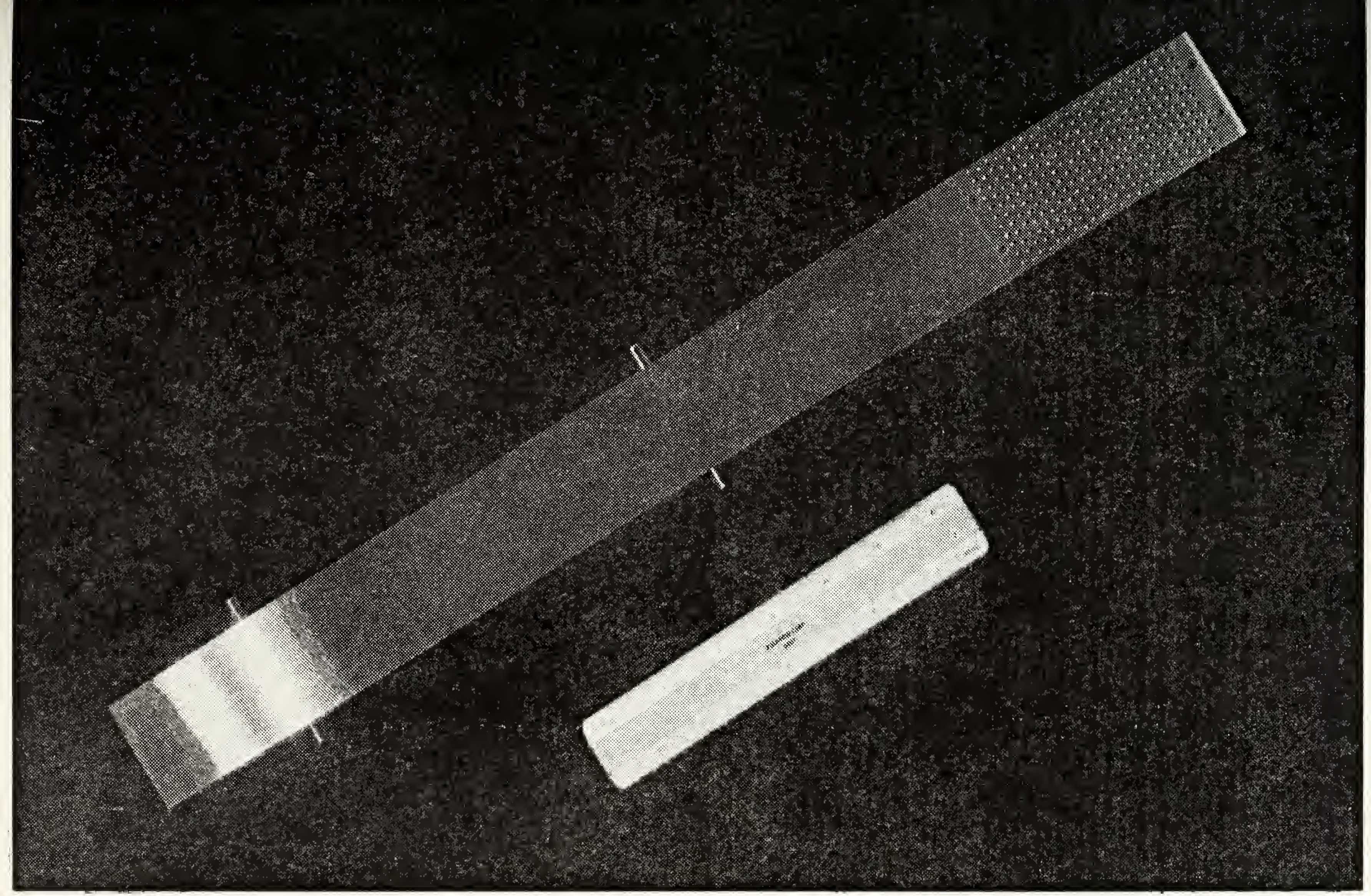


Figure A.4c Assembled Upper Nozzle Block Modification Bottom View

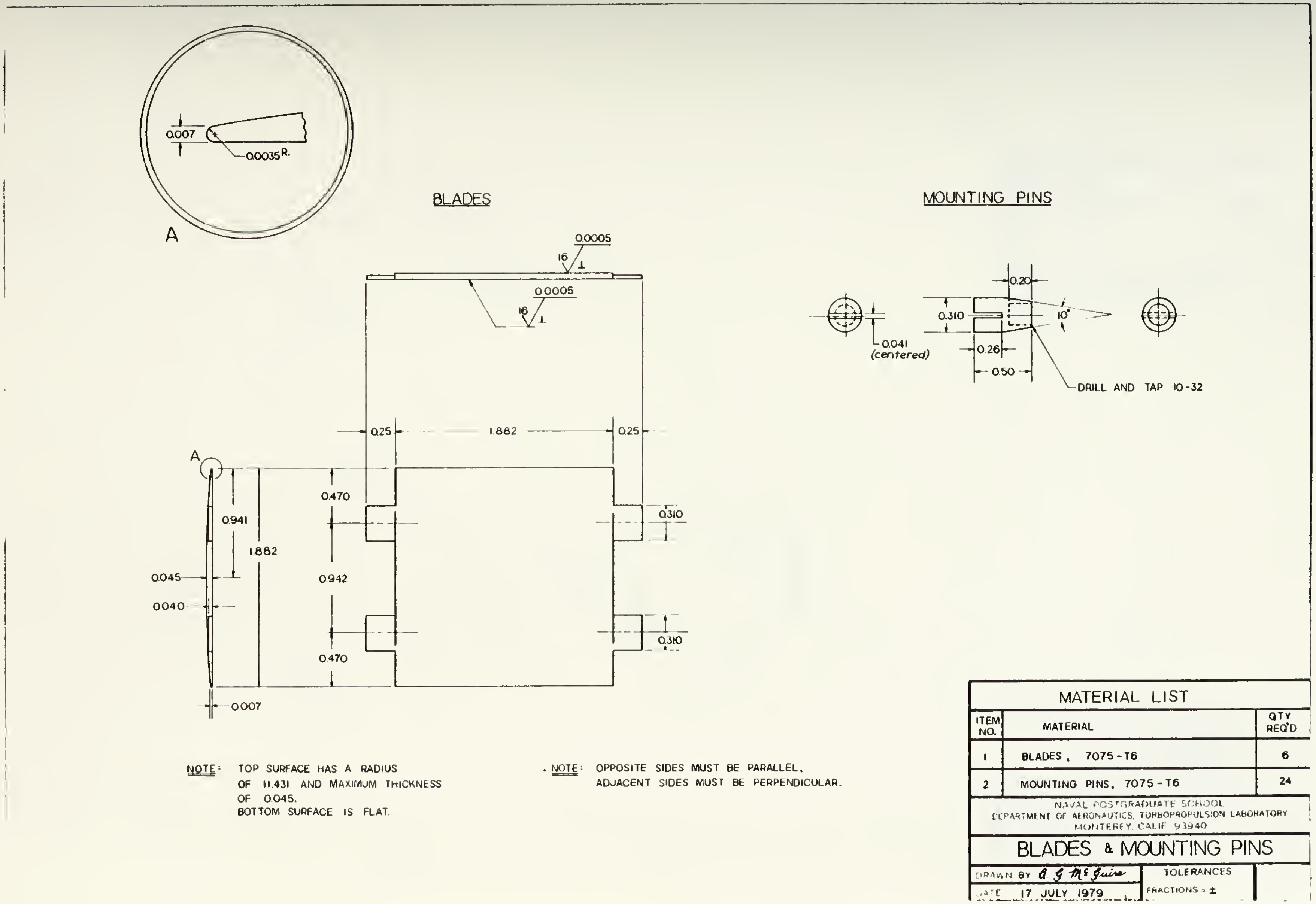
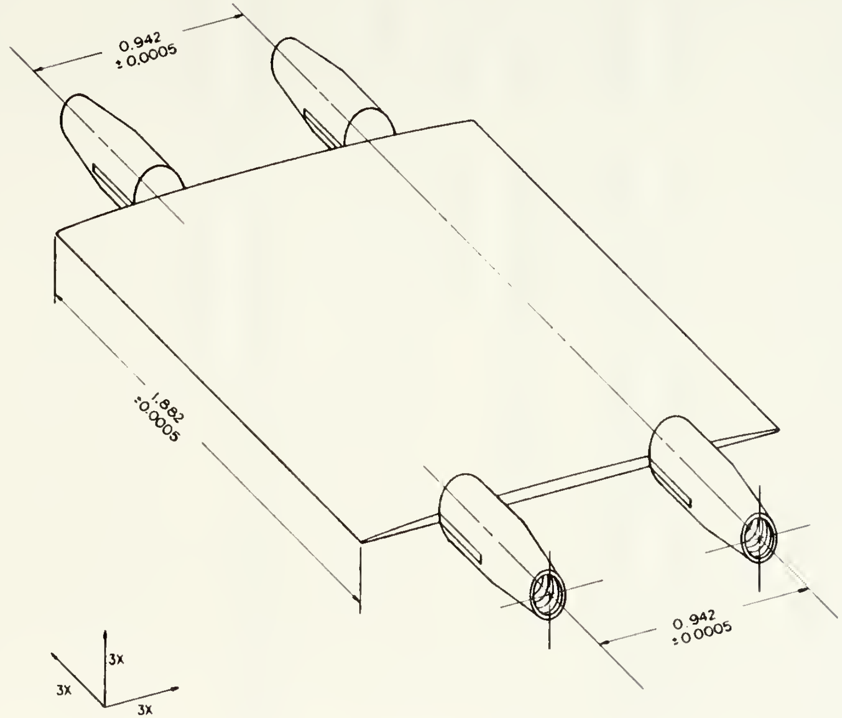


Figure A.5a Blades Mounting Pins



NOTES

1. MOUNTING PINS SHOULD BE BONDED TO THE BLADES USING SCOTCH-WELD BRAND STRUCTURAL ADHESIVE 2214 HI-FLEX OR SIMILAR MATERIAL PROVIDING HIGH FLEXURAL STRENGTH.
2. CONTOURED BLADE SURFACE, TOP AND BOTTOM, WITHIN 1.882 DIMENSIONS SHOULD BE FREE OF BONDING MATERIAL.
3. FINISHED PART SHOULD BE WITHIN TOLERANCES SHOWN.
4. CENTERLINES OF CORRESPONDING PLUGS SHOULD BE COINCIDENT TO ±0.0005 AT EITHER END.
5. CENTERLINES OF PLUGS SHOULD LIE WITHIN THE SAME PLANE, ±0.0005.

NAVAL POSTGRADUATE SCHOOL
DEPARTMENT OF AERONAUTICS TURBOPROPULSION LABORATORY
MONTEREY, CALIF 93940

BLADE ASSEMBLY

DRAWN BY A. J. McGuire	TOLERANCES	
DATE 26 JULY 1979	FRACTIONS = ±	
SCALE AS SHOWN	DECIMALS	
DIMENSIONS ARE IN INCHES	0.X = ±	SHEET 1
DRAWING NO. 5108D	0.XX = ± 0.XXX = ± ANGLES =	OF 1

Figure A.5b Blade Assembly

APPENDIX B

DATA ACQUISITION SYSTEM

B1. SYSTEM HARDWARE

The Hewlett Packard model 3052A/9845A Automatic Data Acquisition System was used for both data acquisition and reduction. The system was augmented with the HG-78K Scanivalve Controller [Reference 8] and two 48 port Scanivalves[1]. The components of the HP 3052A data acquisition system are:

(1) HP-9845A Desk Top Computer/Controller,

(2) HP-3455A High Resolution/High Accuracy Digital Voltmeter,

(3) HP-3437A System Voltmeter,

(4) HP-3495A Scanner

(5) 98035A Real Time Clock

(6) HP-IB[2]

The integrated data acquisition system (Figure B.1) is shown schematically in Figure B.2

---

[1]"Scanivalve" is the registered trademark for a mechanical pneumatic selector switch manufactured by Scanivalve Corporation, P.O. Box 20005, San Diego, California 92120.

[2]The HP-IB is the Hewlett-Packard implementation of IEEE Standard 488-1975, "Digital Interface for Programmable Instrumentation".

B2. DATA ACQUISITION AND REDUCTION PROGRAM

The modified BASIC Program "CASDAT" was written to acquire, store, and reduce data using the Hewlett-Packard HP 9845A computer and peripherials described above. The program is interactive with the operator and as such can be used for either data acquisition and storage or data reduction and storage, or both. The HP 3052A Data Acquisition System Software Package contains a large number of subprograms to simplify and expedite the data acquisition process, and several have been merged into Program "CASDAT".

The program listing provided in Table B-1 is self explanatory in that neumonic variable names are used. The program also contains remark (REM) statements to aid interpretation.

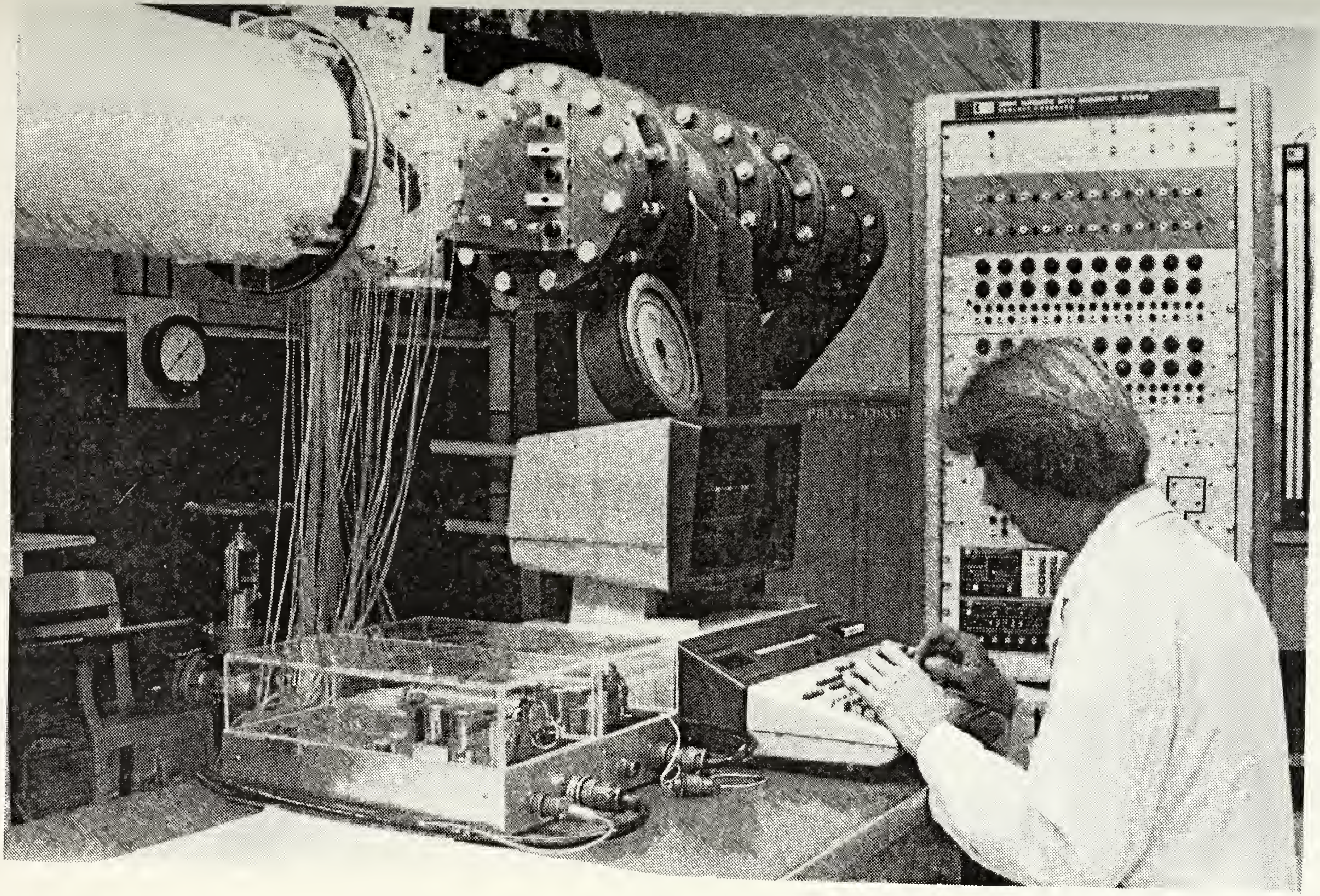


Figure B.1 Cascade Wind Tunnel Data Acquisition System

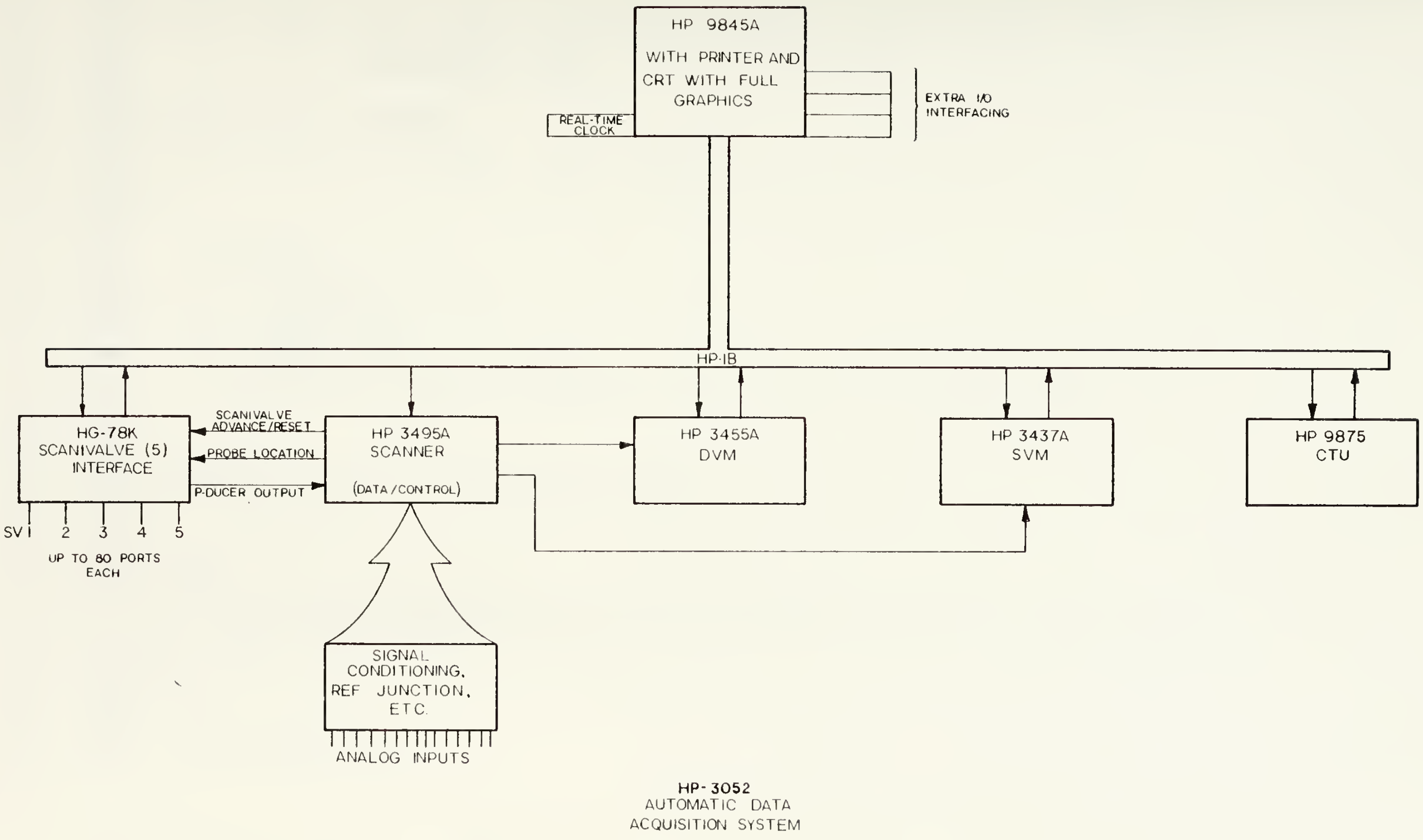


Figure B.2 Cascade Wind Tunnel Data Acquisition System Block Diagram

```
10 REM                    FILE NAME: "CASDAT"
20   REM
30   REM
40   REM DESCRIPTION: THIS PROGRAM PERFORMS SEQUENTIAL SCANNING OF SCANIVALVE
50   REM                "V" BETWEEN PORT ADDRESSES SPECIFIED.IT RECORDS, STORES
60   REM                AND REDUCES DATA.
70   REM
80   REM AUTHOR: K.F. VOLLAND
90   REM
100  REM  ++++++++++++++++++**PART 1 DATA ACQUISITION ++++++++++++++++++++++
110  REM
120  REM
130  REM     VARIABLES:
140  REM     V= DESIRED SCANIVALVE
150  REM     A1= LOW PORT
160  REM     A2= HIGH PORT
170  REM     P= PRESENT SCANIVALVE PORT
180  REM     S= STEP SIZE ! As the program is now s=1 only can be used
190  REM
200  REM
210 OPTION BASE 1
220  DISP "IF YOU DESIRE TO REDUCE DATA ENTER 1";
230  INPUT C
240  IF C<>1 THEN 260
250  GOTO 1100
260  COM Trm,Scn,Dvm,Svm,Bus,Error
270  DIM Measurements(51),Filename$(6),Fileresults$(6),Pressure(46),Mach(46),Pre
ssureratio(46),Port(46)
280  PRINTER IS 16
290  CALL Init
300  CALL Dvm(1,7,0,0)
310  DISP "Scanivalve# ";
```

Table B-1. BASIC PROGRAM "CASDAT"

```
320  INPUT V
330  REM
340  REM THIS PART OF THE PROGRAM ASSIGNS THE REQUIRED SCANNER CHANNELS TO THEIR
         FUNCTIONS FOR THE SCANIVALVE SELECTED.
350  IF V=1 THEN 400
360  IF V=2 THEN 440
370  IF V=3 THEN 480
380  IF V=4 THEN 520
390  IF V=5 THEN 560
400  Reset=45
410  Advance1=40
420  Dataread=0
430  GOTO 590
440  Reset=46
450  Advance1=41
460  Dataread=1
470  GOTO 590
480  Reset=47
490  Advance1=42
500  Dataread=2
510  GOTO 590
520  Reset=48
530  Advance1=43
540  Dataread=3
550  GOTO 590
560  Reset=49
570  Advance1=44
580  Dataread=4
590  CALL Chan(1,Reset) ! Resets selected scanivalve to port 1
600  WAIT 20
610  RESET Scn
620  DISP "Low,High";
630  INPUT A1,A2
640  DISP "STEP SIZE";
```

```
650  INPUT S
660  REM INPUT NON-SCANIVALVE REQUIRED DATA
670  DISP "Ambient Pressure";
680  INPUT Measurements(A2+1)
690  Measurements(A2+1)=Measurements(A2+1)*.4*116
700  DISP "Total Temperature";
710  INPUT Measurements(A2+2)
720  DISP "Total Pressure";
730  INPUT Measurements(A2+3)
740  PRINTER IS 0
750  CALL Time ! This dates all data sheets
760  PRINT
760  PRINT "Scanivalve No.";V
780  PRINT
790  IF A1=1 THEN 850
800  FOR I=1 TO A1-1 ! This loop advances the scanivalve to the first port to be
 scanned in the run
810  CALL Chan(1,Advance1)
820  WAIT 40
830  RESET Scn
840  NEXT I
850  FOR K=A1 TO A2 ! This loop takes readings on the desired sequential scanniva
lve ports
860  CALL Chan(1,Dataread)
870  REM WAIT 10
880  Measurements(K)=FNRdvm
890 Measurements(K)=Measurements(K)*1000
900  PRINT USING Output;K,Measurements(K)
910 Output: IMAGE "Scanivalve Port Number ",DDD,15X,"Pressure = ",DDDDD.DDDDDD,
"  Psig "
920  CALL Chan(1,Advance1)
```

```
930  WAIT 20
940  RESET Scn
950  NEXT K
960  DISP "Insert Data File Name";
970  INPUT Filename$
980  CREATE Filename$,2 ! Creates a raw data file
990  ASSIGN #1 TO Filename$
1000 PRINT #1;Measurements(*)
1010 PRINT "Data Saved In File ",Filename$
1020 PRINT PAGE
1030 PRINTER IS 0
1040 DISP "ENTER 1 IF ANOTHER DATA RUN DESIRED"; ! Gives the choice of taking mo
re data or going on to the data reduction part of the program
1050 INPUT D
1060 IF D=1 THEN 260
1070 REM
1080 REM
1090 REM
1100 REM *****************PART 2 DATA REDUCTION *********************
1110 REM
1120 REM
1130 REM
1140  REM OPTION BASE 1
1150 DISP "INPUT DATA NAME OF DATA FILE O BE REDUCED";
1160 INPUT Filename$
1170 ASSIGN #3 TO Filename$
1180 READ #3;Measurements(*)
1190 CALL Time
1200 PRINT "Reduced data from data file  ;Filename$
1210 DISP "NUMBER OF PRESSURE TAPS THIS RUN";
1220 INPUT A2
1230 PRINT
1240 PRINT
1250 REM PRINT "Total Pressure=",Measurements(A2+1)+Measurements(3),"Psia"
1260 PRINT "Total Pressure= 50.729 psia"
```

```
1270 PRINT
1280 PRINT "Total Temperature=",Measurements(A2+2),"Degrees F."
1290 PRINT
1300 PRINT "Ambient Pressure=",Measurements(A2+1),"Psia"
1310 PRINT
1320 PRINT
1330 PRINT
1340 FOR J=1 TO 46
1350 Pressure(J)=Measurements(J+2)-Measurements(1)+Measurements(A2+1)
1360 REM Pressureratio(J)=(Measurements(A2+1)+Measurements(3))/Pressure(J)
1370 Pressureratio(J)=50.729/Pressure(J)
1380 Mach(J)=(5*(Pressureratio(J)^(1/3.5)-1))^.5
1390 Port(J)=J
1400 Pressureratio(J)=1/Pressureratio(J)
1410 PRINT USING Reduceddata;Port(J),Pressure(J),Pressureratio(J),Mach(J)
1420 Reduceddata: IMAGE "Static Pressure Port",DDD,"  Pressure=",DDDD.DDDD," Psia",2X,"P/Pt0=",DD.DDDDD,"  Mach=",DDD.DDDD
1430 NEXT J
1440 DISP "Input Reduced Data File Name";
1450 INPUT Fileresults$
1460 CREATE Fileresults$,8
1470 ASSIGN #2 TO Fileresults$
1480 PRINT #2;Port(*),Pressure(*),Mach(*),Pressureratio(*)
1490 PRINT "Reduced Data Stored In File ",Fileresults$
1500 PRINT PAGE
1510 DISP "ENTER 1 IF YOU DESIRE TO REDUCE MORE DATA";
1520 INPUT Z
1530 IF Z=1 THEN 1150
1540 END
1550 SUB Init
1560 COM Tmr,Scn,Dvm,Svm,Bus,Error
1570 DATA 9,709,722,724,7
```

```
1590 READ Tmr,Scn,Dvm,Svm,Bus
1590 ABORTIO Bus
1600 REMOTE Bus
1610 RESET Bus
1620 READ IO Tmr,5;Sig
1630 IF BINAND(Sig,48)=32 THEN OUTPUT Tmr USING "A";"S"
1640 SUBEND
1650 SUB Dvm(Function,Range,High_res,Data_rqs)
1660 COM Tmr,Scn,Dvm,Svm,Bus,Error
1670 Error=(Function<1) OR (Function>6)+2*((Range<1) OR (Range>7))
1680 RESET Dvm
1690 OUTPUT Dvm USING Fmt;Function,Range,High_res=1,Data_rqs=1
1700 Fmt: IMAGE "F",D,"R",D,"H",D,"D",D,"T3"
1710 SUBEND
1720 SUB Chan(Clear,Channel)
1730 COM Tmr,Scn,Dvm,Svm,Bus,Error
1740 Offset=ABS(Channel) DIV 80
1750 Error=(Scn MOD 100+Offset)>30)
1760 IF NOT Error AND (Clear=1) THEN RESET Scn+Offset
1770 IF NOT Error AND (Channel<>0) THEN OUTPUT Scn+Offset USING "2D";INT(Channel)
-80*Offset
1780 SUBEND
1790 DEF FNRdvm
1800 COM Tmr,Scn,Dvm,Svm,Bus,Error
1810 TRIGGER Dvm
1820 IF F< A1 THEN 1840
1830 WAIT 100
1840 WAIT 50
1850 ENTER Dvm USING "F";Reading
1860 RETURN Reading
1870 FNEND
1880 SUB Time
1890 COM Tmr,Scn,Dvm,Svm,Bus,Error
1900 OUTPUT 9;"Request time"
```

```
1590 READ Tmr,Scn,Dvm,Svm,Bus
1590 ABORTIO Bus
1600 REMOTE Bus
1610 RESET Bus
1620 READ IO Tmr,5;Sig
1630 IF BINAND(Sig,48)=32 THEN OUTPUT Tmr USING "A";"E"
1640 SUBEND
1650 SUB Dvm(Function,Range,High_res,Data_rqs)
1660 COM Tmr,Scn,Dvm,Svm,Bus,Error
1670 Error=(Function<1) OR (Function>6)+2*((Range<1) OR (Range>
1680 RESET Dvm
1690 OUTPUT Dvm USING Fmt;Function,Range,High_res=1,Data_rqs=1
1700 Fmt: IMAGE "F",D,"R",D,"H",D,"D",D,"T3"
1710 SUBEND
1720 SUB Chan(Clear,Channel)
1730 COM Tmr,Scn,Dvm,Svm,Bus,Error
1740 Offset=ABS(Channel) DIV 80
1750 Error=(Scn MOD 100+Offset>30)
1760 IF NOT Error AND (Clear=1) THEN RESET Scn+Offset
1770 IF NOT Error AND (Channel>=0) THEN OUTPUT Scn+Offset USING "DD";INT(Channel
-80*Offset
1780 SUBEND
1790 DEF FNRdvm
1800 COM Tmr,Scn,Dvm,Svm,Bus,Error
1810 TRIGGER Dvm
1820 IF F<>A1 THEN 1840
1830 WAIT 100
1840 WAIT 50
1850 ENTER Dvm USING "F";Reading
1860 RETURN Reading
1870 FNEND
1880 SUB Time
1890 COM Tmr,Scn,Dvm,Svm,Bus,Error
1900 OUTPUT 9;"Request time"
```

```
1910 ENTER 9;Month,Day,Hour,Time$
1920 DIM Month$(12)[5],Mer$(2)
1930 INTEGER Hour
1940 RESTORE
1950 FOR I=1 TO 12
1960 READ Month$(I)
1970 NEXT I
1980 DATA JAN,FEB,MAR,APR,MAY,JUNE,JULY,AUG,SEPT,OCT,NOV,DEC
1990 Mer$="AM"
2000 IF Hour>11 THEN Mer$="PM"
2010 IF Hour>12 THEN Hour=Hour-12
2020 IF Hour=0 THEN Hour=12
2030 PRINT Month$(Month);Day,Hour;":";Time$;"  ";Mer$
2040 SUBEND
```

APPENDIX C

TEST DATA

The results of the Calibration Tests, Initial Cascade Tests, and perforated wall Wave Cancellation Tests are given in Tables C-1, C-2 and C-3 respectively.

++++++++++++++++++++ CALIBRATION TEST 1 ++++++++++++++++++++++++++++

al Pressure = 52.274 psia
enum Total Temperature = 52 deg F
bient Pressure = 14.823 psia

ap No. 1	Static Pressure= 52.274	P/Pt0=1.0000	Mach= 0.000
ap No. 2	Static Pressure= 17.320	P/Pt0= .3313	Mach= 1.362
ap No. 3	Static Pressure= 17.192	P/Pt0= .3289	Mach= 1.367
ap No. 4	Static Pressure= 17.560	P/Pt0= .3359	Mach= 1.352
ap No. 5	Static Pressure= 17.359	P/Pt0= .3321	Mach= 1.361
ap No. 6	Static Pressure= 17.763	P/Pt0= .3398	Mach= 1.344
ap No. 7	Static Pressure= 17.337	P/Pt0= .3317	Mach= 1.361
ap No. 8	Static Pressure= 17.493	P/Pt0= .3346	Mach= 1.355
ap No. 9	Static Pressure= 17.061	P/Pt0= .3264	Mach= 1.373
ap No. 10	Static Pressure= 17.336	P/Pt0= .3316	Mach= 1.361
ap No. 11	Static Pressure= 17.229	P/Pt0= .3296	Mach= 1.366
No. 12	Static Pressure= 17.190	P/Pt0= .3288	Mach= 1.368
ap No. 13	Static Pressure= 16.602	P/Pt0= .3176	Mach= 1.392
ap No. 14	Static Pressure= 15.763	P/Pt0= .3015	Mach= 1.429
ap No. 15	Static Pressure= 17.248	P/Pt0= .3300	Mach= 1.365
ap No. 16	Static Pressure= 16.992	P/Pt0= .3251	Mach= 1.376
ap No. 17	Static Pressure= 16.701	P/Pt0= .3195	Mach= 1.388
ap No. 18	Static Pressure= 16.572	P/Pt0= .3170	Mach= 1.394
ap No. 19	Static Pressure= 16.732	P/Pt0= .3201	Mach= 1.387
ap No. 20	Static Pressure= 16.308	P/Pt0= .3120	Mach= 1.405
ap No. 21	Static Pressure= 17.435	P/Pt0= .3335	Mach= 1.357
ap No. 22	Static Pressure= 14.794	P/Pt0= .2830	Mach= 1.474
ap No. 23	Static Pressure= 13.603	P/Pt0= .2602	Mach= 1.531
ap No. 24	Static Pressure= 17.909	P/Pt0= .3426	Mach= 1.338
ap No. 25	Static Pressure= 15.853	P/Pt0= .3033	Mach= 1.425
ap No. 26	Static Pressure= 14.736	P/Pt0= .2819	Mach= 1.476
ap No. 27	Static Pressure= 14.410	P/Pt0= .2757	Mach= 1.492
ap No. 28	Static Pressure= 14.040	P/Pt0= .2686	Mach= 1.510
ap No. 29	Static Pressure= 13.966	P/Pt0= .2672	Mach= 1.513
ap No. 30	Static Pressure= 13.806	P/Pt0= .2641	Mach= 1.521
ap No. 31	Static Pressure= 12.990	P/Pt0= .2485	Mach= 1.563
ap No. 32	Static Pressure= 12.285	P/Pt0= .2350	Mach= 1.601
ap No. 33	Static Pressure= 16.476	P/Pt0= .3152	Mach= 1.398
ap No. 34	Static Pressure= 14.358	P/Pt0= .2747	Mach= 1.494
ap No. 35	Static Pressure= 13.759	P/Pt0= .2632	Mach= 1.524
ap No. 36	Static Pressure= 13.445	P/Pt0= .2572	Mach= 1.539
ap No. 37	Static Pressure= 13.413	P/Pt0= .2566	Mach= 1.541
Tap No. 38	Static Pressure= 13.187	P/Pt0= .2523	Mach= 1.553
Tap No. 39	Static Pressure= 13.072	P/Pt0= .2501	Mach= 1.559
ap No. 40	Static Pressure= 12.482	P/Pt0= .2388	Mach= 1.590
ap No. 41	Static Pressure= 12.144	P/Pt0= .2323	Mach= 1.609
No. 42	Static Pressure= 13.304	P/Pt0= .2545	Mach= 1.547
ap No. 43	Static Pressure= 12.831	P/Pt0= .2455	Mach= 1.571
ap No. 44	Static Pressure= 14.761	P/Pt0= .2824	Mach= 1.475
ap No. 45	Static Pressure= 12.811	P/Pt0= .2451	Mach= 1.572
Tap No. 46	Static Pressure= 12.563	P/Pt0= .2403	Mach= 1.586

Table C-1. Calibration Test Data

IBRATION TEST 1 CONTINUED

ap No. 47	Static Pressure= 12.919	P/Pt0= .2471	Mach= 1.567
ap No. 48	Static Pressure= 12.468	P/Pt0= .2385	Mach= 1.591
ap No. 49	Static Pressure= 12.235	P/Pt0= .2341	Mach= 1.603
ap No. 50	Static Pressure= 12.413	P/Pt0= .2375	Mach= 1.594
ap No. 51	Static Pressure= 11.907	P/Pt0= .2278	Mach= 1.622
ap No. 52	Static Pressure= 11.905	P/Pt0= .2277	Mach= 1.622
ap No. 53	Static Pressure= 11.888	P/Pt0= .2274	Mach= 1.623
ap No. 54	Static Pressure= 11.954	P/Pt0= .2287	Mach= 1.619
ap No. 55	Static Pressure= 11.690	P/Pt0= .2236	Mach= 1.634
ap No. 56	Static Pressure= 11.683	P/Pt0= .2235	Mach= 1.635
ap No. 57	Static Pressure= 11.773	P/Pt0= .2252	Mach= 1.629
ap No. 58	Static Pressure= 11.700	P/Pt0= .2238	Mach= 1.634
ap No. 59	Static Pressure= 14.735	P/Pt0= .2819	Mach= 1.476
ap No. 60	Static Pressure= 12.099	P/Pt0= .2315	Mach= 1.611
ap No. 61	Static Pressure= 12.087	P/Pt0= .2312	Mach= 1.612
ap No. 62	Static Pressure= 11.720	P/Pt0= .2242	Mach= 1.632
ap No. 63	Static Pressure= 11.817	P/Pt0= .2261	Mach= 1.627
ap No. 64	Static Pressure= 11.981	P/Pt0= .2292	Mach= 1.618
ap No. 65	Static Pressure= 11.726	P/Pt0= .2243	Mach= 1.632
ap No. 66	Static Pressure= 11.806	P/Pt0= .2259	Mach= 1.628
ap No. 67	Static Pressure= 11.909	P/Pt0= .2278	Mach= 1.622
ap No. 68	Static Pressure= 12.756	P/Pt0= .2440	Mach= 1.575
ap No. 69	Static Pressure= 11.847	P/Pt0= .2266	Mach= 1.625
ap No. 70	Static Pressure= 11.287	P/Pt0= .2159	Mach= 1.658
ap No. 71	Static Pressure= 12.016	P/Pt0= .2299	Mach= 1.616
ap No. 72	Static Pressure= 17.005	P/Pt0= .3253	Mach= 1.375
ap No. 73	Static Pressure= 15.207	P/Pt0= .2909	Mach= 1.454
ap No. 74	Static Pressure= 10.930	P/Pt0= .2091	Mach= 1.679
ap No. 75	Static Pressure= 17.142	P/Pt0= .3279	Mach= 1.370
ap No. 76	Static Pressure= 17.132	P/Pt0= .3277	Mach= 1.370
ap No. 77	Static Pressure= 14.832	P/Pt0= .2837	Mach= 1.472
ap No. 78	Static Pressure= 14.802	P/Pt0= .2832	Mach= 1.473
ap No. 79	Static Pressure= 13.398	P/Pt0= .2563	Mach= 1.542
ap No. 80	Static Pressure= 14.754	P/Pt0= .2822	Mach= 1.475
ap No. 81	Static Pressure= 14.790	P/Pt0= .2829	Mach= 1.474
ap No. 82	Static Pressure= 14.789	P/Pt0= .2829	Mach= 1.474
ap No. 83	Static Pressure= 14.781	P/Pt0= .2828	Mach= 1.474
ap No. 84	Static Pressure= 11.969	P/Pt0= .2290	Mach= 1.618
ap No. 85	Static Pressure= 14.709	P/Pt0= .2814	Mach= 1.478
ap No. 86	Static Pressure= 14.822	P/Pt0= .2835	Mach= 1.472
ap No. 87	Static Pressure= 17.189	P/Pt0= .3288	Mach= 1.368
ap No. 88	Static Pressure= 15.294	P/Pt0= .2926	Mach= 1.450
ap No. 89	Static Pressure= 10.921	P/Pt0= .2089	Mach= 1.680

Table C-1. (Continued)

*********************** CALIBRATION TEST 2 ******************************

al Pressure = 49.500 psia
num Total Temperature = 61 deg F
ient Pressure = 14.774 psia

ap No. 1	Static Pressure= 49.482	P/Pt0= .9996	Mach= .023
ap No. 2	Static Pressure= 16.299	P/Pt0= .3293	Mach= 1.367
ap No. 3	Static Pressure= 16.193	P/Pt0= .3271	Mach= 1.371
ap No. 4	Static Pressure= 16.423	P/Pt0= .3318	Mach= 1.361
ap No. 5	Static Pressure= 16.394	P/Pt0= .3312	Mach= 1.362
ap No. 6	Static Pressure= 16.791	P/Pt0= .3392	Mach= 1.345
ap No. 7	Static Pressure= 16.414	P/Pt0= .3316	Mach= 1.362
ap No. 8	Static Pressure= 16.562	P/Pt0= .3346	Mach= 1.355
ap No. 9	Static Pressure= 16.158	P/Pt0= .3264	Mach= 1.373
ap No. 10	Static Pressure= 16.209	P/Pt0= .3275	Mach= 1.371
ap No. 11	Static Pressure= 16.284	P/Pt0= .3290	Mach= 1.367
ap No. 12	Static Pressure= 16.250	P/Pt0= .3283	Mach= 1.369
ap No. 13	Static Pressure= 15.592	P/Pt0= .3150	Mach= 1.398
ap No. 14	Static Pressure= 14.847	P/Pt0= .2999	Mach= 1.433
ap No. 15	Static Pressure= 16.360	P/Pt0= .3305	Mach= 1.364
ap No. 16	Static Pressure= 16.160	P/Pt0= .3265	Mach= 1.373
ap No. 17	Static Pressure= 15.837	P/Pt0= .3199	Mach= 1.387
ap No. 18	Static Pressure= 15.693	P/Pt0= .3170	Mach= 1.394
ap No. 19	Static Pressure= 15.922	P/Pt0= .3217	Mach= 1.383
ap No. 20	Static Pressure= 15.510	P/Pt0= .3133	Mach= 1.402
ap No. 21	Static Pressure= 15.138	P/Pt0= .3058	Mach= 1.419
ap No. 22	Static Pressure= 14.090	P/Pt0= .2846	Mach= 1.470
ap No. 23	Static Pressure= 12.976	P/Pt0= .2621	Mach= 1.526
ap No. 24	Static Pressure= 16.657	P/Pt0= .3365	Mach= 1.351
ap No. 25	Static Pressure= 15.141	P/Pt0= .3059	Mach= 1.419
ap No. 26	Static Pressure= 13.979	P/Pt0= .2824	Mach= 1.475
ap No. 27	Static Pressure= 13.780	P/Pt0= .2784	Mach= 1.485
ap No. 28	Static Pressure= 13.352	P/Pt0= .2697	Mach= 1.507
ap No. 29	Static Pressure= 13.336	P/Pt0= .2694	Mach= 1.508
ap No. 30	Static Pressure= 13.171	P/Pt0= .2661	Mach= 1.516
ap No. 31	Static Pressure= 12.589	P/Pt0= .2543	Mach= 1.547
ap No. 32	Static Pressure= 11.947	P/Pt0= .2414	Mach= 1.583
ap No. 33	Static Pressure= 15.603	P/Pt0= .3152	Mach= 1.398
ap No. 34	Static Pressure= 13.662	P/Pt0= .2760	Mach= 1.491
ap No. 35	Static Pressure= 13.247	P/Pt0= .2676	Mach= 1.512
ap No. 36	Static Pressure= 12.884	P/Pt0= .2603	Mach= 1.531
ap No. 37	Static Pressure= 12.908	P/Pt0= .2608	Mach= 1.530
ap No. 38	Static Pressure= 12.681	P/Pt0= .2562	Mach= 1.542
ap No. 39	Static Pressure= 12.639	P/Pt0= .2553	Mach= 1.544
ap No. 40	Static Pressure= 12.151	P/Pt0= .2455	Mach= 1.571
ap No. 41	Static Pressure= 11.875	P/Pt0= .2399	Mach= 1.587
ap No. 42	Static Pressure= 12.990	P/Pt0= .2624	Mach= 1.526
ap No. 43	Static Pressure= 12.535	P/Pt0= .2532	Mach= 1.550
ap No. 44	Static Pressure= 12.699	P/Pt0= .2565	Mach= 1.541
ap No. 45	Static Pressure= 12.451	P/Pt0= .2515	Mach= 1.555
ap No. 46	Static Pressure= 12.349	P/Pt0= .2495	Mach= 1.560

Table C-1. (Continued)

CLIBRATION TEST 2 CONTINUED

ap No. 47	Static Pressure= 12.621	P/Pt0= .2550	Mach= 1.545
ap No. 48	Static Pressure= 12.249	P/Pt0= .2475	Mach= 1.566
ap No. 49	Static Pressure= 12.124	P/Pt0= .2449	Mach= 1.573
ap No. 50	Static Pressure= 12.131	P/Pt0= .2451	Mach= 1.572
ap No. 51	Static Pressure= 11.699	P/Pt0= .2363	Mach= 1.597
ap No. 52	Static Pressure= 11.906	P/Pt0= .2405	Mach= 1.585
ap No. 53	Static Pressure= 11.807	P/Pt0= .2385	Mach= 1.591
ap No. 54	Static Pressure= 11.928	P/Pt0= .2410	Mach= 1.584
ap No. 55	Static Pressure= 11.758	P/Pt0= .2375	Mach= 1.594
ap No. 56	Static Pressure= 11.792	P/Pt0= .2382	Mach= 1.592
ap No. 57	Static Pressure= 12.105	P/Pt0= .2445	Mach= 1.574
ap No. 58	Static Pressure= 12.093	P/Pt0= .2443	Mach= 1.575
ap No. 59	Static Pressure= 12.618	P/Pt0= .2549	Mach= 1.546
ap No. 60	Static Pressure= 12.556	P/Pt0= .2537	Mach= 1.549
ap No. 61	Static Pressure= 12.141	P/Pt0= .2453	Mach= 1.572
ap No. 62	Static Pressure= 11.940	P/Pt0= .2412	Mach= 1.583
ap No. 63	Static Pressure= 12.226	P/Pt0= .2470	Mach= 1.567
ap No. 64	Static Pressure= 12.033	P/Pt0= .2431	Mach= 1.578
ap No. 65	Static Pressure= 11.823	P/Pt0= .2389	Mach= 1.590
ap No. 66	Static Pressure= 11.781	P/Pt0= .2380	Mach= 1.592
ap No. 67	Static Pressure= 12.281	P/Pt0= .2481	Mach= 1.564
ap No. 68	Static Pressure= 12.741	P/Pt0= .2574	Mach= 1.539
ap No. 69	Static Pressure= 11.826	P/Pt0= .2389	Mach= 1.590
ap No. 70	Static Pressure= 11.444	P/Pt0= .2312	Mach= 1.612
ap No. 71	Static Pressure= 12.223	P/Pt0= .2469	Mach= 1.567
ap No. 72	Static Pressure= 16.067	P/Pt0= .3246	Mach= 1.377
ap No. 73	Static Pressure= 14.363	P/Pt0= .2902	Mach= 1.456
ap No. 74	Static Pressure= 11.498	P/Pt0= .2323	Mach= 1.609
ap No. 75	Static Pressure= 16.193	P/Pt0= .3271	Mach= 1.371
ap No. 76	Static Pressure= 16.060	P/Pt0= .3244	Mach= 1.377
ap No. 77	Static Pressure= 14.771	P/Pt0= .2984	Mach= 1.437
ap No. 78	Static Pressure= 14.803	P/Pt0= .2991	Mach= 1.435
ap No. 79	Static Pressure= 12.856	P/Pt0= .2597	Mach= 1.533
ap No. 80	Static Pressure= 14.697	P/Pt0= .2969	Mach= 1.440
Tap No. 81	Static Pressure= 14.749	P/Pt0= .2980	Mach= 1.438
Tap No. 82	Static Pressure= 14.744	P/Pt0= .2979	Mach= 1.438
Tap No. 83	Static Pressure= 14.745	P/Pt0= .2979	Mach= 1.438
Tap No. 84	Static Pressure= 11.817	P/Pt0= .2387	Mach= 1.590
Tap No. 85	Static Pressure= 14.686	P/Pt0= .2967	Mach= 1.441
Tap No. 86	Static Pressure= 14.836	P/Pt0= .2997	Mach= 1.433
Tap No. 87	Static Pressure= 16.235	P/Pt0= .3280	Mach= 1.369
Tap No. 88	Static Pressure= 14.667	P/Pt0= .2963	Mach= 1.441
Tap No. 89	Static Pressure= 11.579	P/Pt0= .2339	Mach= 1.604

Table C-1. (Continued)

]tal Pressure = 50.728 psia
?enum Total Temperature = 62 deg F
Abient Pressure = 14.749 psia

ap No. 1	Static Pressure = 50.729 psia	P/Pt0=1.0000
ap No. 2	Static Pressure = 33.355 psia	P/Pt0= .6575
ap No. 3	Static Pressure = 33.863 psia	P/Pt0= .6675
ap No. 4	Static Pressure = 33.928 psia	P/Pt0= .6688
ap No. 5	Static Pressure = 33.970 psia	P/Pt0= .6696
ap No. 6	Static Pressure = 33.449 psia	P/Pt0= .6594
ap No. 7	Static Pressure = 33.977 psia	P/Pt0= .6698
ap No. 8	Static Pressure = 34.040 psia	P/Pt0= .6710
ap No. 9	Static Pressure = 34.066 psia	P/Pt0= .6715
ap No. 10	Static Pressure = 34.075 psia	P/Pt0= .6717
ap No. 11	Static Pressure = 33.900 psia	P/Pt0= .6683
ap No. 12	Static Pressure = 33.847 psia	P/Pt0= .6672
ap No. 13	Static Pressure = 33.721 psia	P/Pt0= .6647
ap No. 14	Static Pressure = 33.578 psia	P/Pt0= .6619
ap No. 15	Static Pressure = 33.595 psia	P/Pt0= .6622
ap No. 16	Static Pressure = 33.986 psia	P/Pt0= .6699
ap No. 17	Static Pressure = 34.002 psia	P/Pt0= .6703
ap No. 18	Static Pressure = 33.761 psia	P/Pt0= .6655
ap No. 19	Static Pressure = 33.706 psia	P/Pt0= .6644
ap No. 20	Static Pressure = 33.706 psia	P/Pt0= .6644
ap No. 21	Static Pressure = 33.828 psia	P/Pt0= .6668
ap No. 22	Static Pressure = 33.408 psia	P/Pt0= .6586
ap No. 23	Static Pressure = 33.054 psia	P/Pt0= .6516
ap No. 24	Static Pressure = 34.652 psia	P/Pt0= .6831
ap No. 25	Static Pressure = 34.395 psia	P/Pt0= .6780
ap No. 26	Static Pressure = 33.497 psia	P/Pt0= .6603
ap No. 27	Static Pressure = 33.968 psia	P/Pt0= .6696
ap No. 28	Static Pressure = 33.941 psia	P/Pt0= .6691
ap No. 29	Static Pressure = 33.494 psia	P/Pt0= .6603
ap No. 30	Static Pressure = 33.180 psia	P/Pt0= .6541
ap No. 31	Static Pressure = 33.862 psia	P/Pt0= .6675
ap No. 32	Static Pressure = 32.642 psia	P/Pt0= .6435
ap No. 33	Static Pressure = 34.206 psia	P/Pt0= .6743
ap No. 34	Static Pressure = 33.751 psia	P/Pt0= .6653
ap No. 35	Static Pressure = 34.487 psia	P/Pt0= .6798
ap No. 36	Static Pressure = 34.031 psia	P/Pt0= .6708
ap No. 37	Static Pressure = 33.360 psia	P/Pt0= .6576
ap No. 38	Static Pressure = 32.817 psia	P/Pt0= .6469
ap No. 39	Static Pressure = 32.866 psia	P/Pt0= .6479
ap No. 40	Static Pressure = 33.141 psia	P/Pt0= .6533
ap No. 41	Static Pressure = 31.082 psia	P/Pt0= .6127
ap No. 42	Static Pressure = 33.469 psia	P/Pt0= .6598
ap No. 43	Static Pressure = 33.031 psia	P/Pt0= .6511
ap No. 44	Static Pressure = 32.508 psia	P/Pt0= .6408
ap No. 45	Static Pressure = 32.453 psia	P/Pt0= .6397
ap No. 46	Static Pressure = 32.444 psia	P/Pt0= .6396

Table C-2. Cascade Wind Tunnel Test Data

ADE WIND TUNNEL TEST 1 CONTINUED

p No. 47	Static Pressure =	32.148 psia	P/Pt0= .6337
p No. 48	Static Pressure =	32.068 psia	P/Pt0= .6321
p No. 49	Static Pressure =	31.239 psia	P/Pt0= .6158
p No. 50	Static Pressure =	23.478 psia	P/Pt0= .4628
p No. 51	Static Pressure =	31.811 psia	P/Pt0= .6271
p No. 52	Static Pressure =	31.204 psia	P/Pt0= .6151
p No. 53	Static Pressure =	29.516 psia	P/Pt0= .5818
p No. 54	Static Pressure =	22.630 psia	P/Pt0= .4461
p No. 55	Static Pressure =	30.574 psia	P/Pt0= .6027
p No. 56	Static Pressure =	28.336 psia	P/Pt0= .5586
p No. 57	Static Pressure =	22.831 psia	P/Pt0= .4500
p No. 58	Static Pressure =	21.312 psia	P/Pt0= .4201
p No. 59	Static Pressure =	21.453 psia	P/Pt0= .4229
p No. 60	Static Pressure =	20.225 psia	P/Pt0= .3987
p No. 61	Static Pressure =	19.392 psia	P/Pt0= .3823
p No. 62	Static Pressure =	16.789 psia	P/Pt0= .3309
p No. 63	Static Pressure =	17.474 psia	P/Pt0= .3444
p No. 64	Static Pressure =	16.948 psia	P/Pt0= .3341
p No. 65	Static Pressure =	14.785 psia	P/Pt0= .2914
p No. 66	Static Pressure =	13.038 psia	P/Pt0= .2570
p No. 67	Static Pressure =	10.107 psia	P/Pt0= .1992
p No. 68	Static Pressure =	10.601 psia	P/Pt0= .2090
p No. 69	Static Pressure =	11.257 psia	P/Pt0= .2219
p No. 70	Static Pressure =	11.883 psia	P/Pt0= .2342
p No. 71	Static Pressure =	11.600 psia	P/Pt0= .2287
p No. 72	Static Pressure =	33.404 psia	P/Pt0= .6585
p No. 73	Static Pressure =	25.629 psia	P/Pt0= .5052
p No. 74	Static Pressure =	22.918 psia	P/Pt0= .4518
p No. 75	Static Pressure =	32.392 psia	P/Pt0= .6385
p No. 76	Static Pressure =	33.525 psia	P/Pt0= .6609
p No. 77	Static Pressure =	15.089 psia	P/Pt0= .2974
p No. 78	Static Pressure =	14.766 psia	P/Pt0= .2911
p No. 79	Static Pressure =	32.923 psia	P/Pt0= .6490
p No. 80	Static Pressure =	15.268 psia	P/Pt0= .3010
p No. 81	Static Pressure =	14.783 psia	P/Pt0= .2914
p No. 82	Static Pressure =	14.762 psia	P/Pt0= .2910
p No. 83	Static Pressure =	10.260 psia	P/Pt0= .2022
p No. 84	Static Pressure =	11.137 psia	P/Pt0= .2195
p No. 85	Static Pressure =	14.610 psia	P/Pt0= .2880
p No. 86	Static Pressure =	14.800 psia	P/Pt0= .2917
p No. 87	Static Pressure =	33.539 psia	P/Pt0= .6611
p No. 88	Static Pressure =	26.185 psia	P/Pt0= .5162
p No. 89	Static Pressure =	23.609 psia	P/Pt0= .4654

Table C-2. (Continued)

Ttal Pressure = 49.565 psia
Penum Total Temperature = 65 deg F
Abient Pressure = 14.789 psia

ap No. 1	Static Pressure = 49.561 psia	P/Pt0= .9999
ap No. 2	Static Pressure = 16.261 psia	P/Pt0= .3281
ap No. 3	Static Pressure = 15.999 psia	P/Pt0= .3228
ap No. 4	Static Pressure = 16.202 psia	P/Pt0= .3269
ap No. 5	Static Pressure = 16.416 psia	P/Pt0= .3312
ap No. 6	Static Pressure = 16.930 psia	P/Pt0= .3416
ap No. 7	Static Pressure = 16.244 psia	P/Pt0= .3277
ap No. 8	Static Pressure = 16.811 psia	P/Pt0= .3392
ap No. 9	Static Pressure = 16.694 psia	P/Pt0= .3368
ap No. 10	Static Pressure = 16.960 psia	P/Pt0= .3422
ap No. 11	Static Pressure = 17.656 psia	P/Pt0= .3562
ap No. 12	Static Pressure = 18.297 psia	P/Pt0= .3691
ap No. 13	Static Pressure = 19.156 psia	P/Pt0= .3865
ap No. 14	Static Pressure = 19.792 psia	P/Pt0= .3993
ap No. 15	Static Pressure = 16.109 psia	P/Pt0= .3250
ap No. 16	Static Pressure = 17.211 psia	P/Pt0= .3472
ap No. 17	Static Pressure = 18.849 psia	P/Pt0= .3803
ap No. 18	Static Pressure = 19.248 psia	P/Pt0= .3883
ap No. 19	Static Pressure = 19.190 psia	P/Pt0= .3872
ap No. 20	Static Pressure = 19.432 psia	P/Pt0= .3920
ap No. 21	Static Pressure = 19.137 psia	P/Pt0= .3861
ap No. 22	Static Pressure = 20.316 psia	P/Pt0= .4099
ap No. 23	Static Pressure = 20.610 psia	P/Pt0= .4158
ap No. 24	Static Pressure = 18.101 psia	P/Pt0= .3652
ap No. 25	Static Pressure = 18.899 psia	P/Pt0= .3813
ap No. 26	Static Pressure = 18.669 psia	P/Pt0= .3767
ap No. 27	Static Pressure = 19.383 psia	P/Pt0= .3911
ap No. 28	Static Pressure = 20.322 psia	P/Pt0= .4100
ap No. 29	Static Pressure = 19.683 psia	P/Pt0= .3971
ap No. 30	Static Pressure = 19.555 psia	P/Pt0= .3945
ap No. 31	Static Pressure = 20.279 psia	P/Pt0= .4091
ap No. 32	Static Pressure = 22.014 psia	P/Pt0= .4441
ap No. 33	Static Pressure = 18.676 psia	P/Pt0= .3768
ap No. 34	Static Pressure = 19.151 psia	P/Pt0= .3864
ap No. 35	Static Pressure = 20.436 psia	P/Pt0= .4123
ap No. 36	Static Pressure = 19.817 psia	P/Pt0= .3998
ap No. 37	Static Pressure = 19.448 psia	P/Pt0= .3924
ap No. 38	Static Pressure = 19.118 psia	P/Pt0= .3857
ap No. 39	Static Pressure = 19.083 psia	P/Pt0= .3850
ap No. 40	Static Pressure = 19.985 psia	P/Pt0= .4032
ap No. 41	Static Pressure = 22.030 psia	P/Pt0= .4445
ap No. 42	Static Pressure = 19.273 psia	P/Pt0= .3888
ap No. 43	Static Pressure = 19.035 psia	P/Pt0= .3840
ap No. 44	Static Pressure = 18.746 psia	P/Pt0= .3782
ap No. 45	Static Pressure = 18.524 psia	P/Pt0= .3737
ap No. 46	Static Pressure = 18.859 psia	P/Pt0= .3805

Table C-2. (Continued)

ap No. 47	Static Pressure = 18.618 psia	P/Pt0= .3756
ap No. 48	Static Pressure = 18.492 psia	P/Pt0= .3731
ap No. 49	Static Pressure = 19.298 psia	P/Pt0= .3893
ap No. 50	Static Pressure = 19.478 psia	P/Pt0= .3930
ap No. 51	Static Pressure = 18.080 psia	P/Pt0= .3648
ap No. 52	Static Pressure = 18.528 psia	P/Pt0= .3738
ap No. 53	Static Pressure = 19.142 psia	P/Pt0= .3862
ap No. 54	Static Pressure = 18.556 psia	P/Pt0= .3744
ap No. 55	Static Pressure = 18.843 psia	P/Pt0= .3802
ap No. 56	Static Pressure = 18.621 psia	P/Pt0= .3757
ap No. 57	Static Pressure = 17.979 psia	P/Pt0= .3627
ap No. 58	Static Pressure = 16.939 psia	P/Pt0= .3417
ap No. 59	Static Pressure = 17.539 psia	P/Pt0= .3539
ap No. 60	Static Pressure = 16.677 psia	P/Pt0= .3365
ap No. 61	Static Pressure = 16.408 psia	P/Pt0= .3310
ap No. 62	Static Pressure = 15.377 psia	P/Pt0= .3102
ap No. 63	Static Pressure = 15.528 psia	P/Pt0= .3133
ap No. 64	Static Pressure = 14.600 psia	P/Pt0= .2946
ap No. 65	Static Pressure = 13.326 psia	P/Pt0= .2689
ap No. 66	Static Pressure = 12.496 psia	P/Pt0= .2521
ap No. 67	Static Pressure = 11.523 psia	P/Pt0= .2325
ap No. 68	Static Pressure = 12.335 psia	P/Pt0= .2489
ap No. 69	Static Pressure = 12.217 psia	P/Pt0= .2465
ap No. 70	Static Pressure = 12.111 psia	P/Pt0= .2443
ap No. 71	Static Pressure = 11.579 psia	P/Pt0= .2336
ap No. 72	Static Pressure = 16.502 psia	P/Pt0= .3329
ap No. 73	Static Pressure = 15.816 psia	P/Pt0= .3191
ap No. 74	Static Pressure = 20.636 psia	P/Pt0= .4163
ap No. 75	Static Pressure = 16.569 psia	P/Pt0= .3343
ap No. 76	Static Pressure = 16.753 psia	P/Pt0= .3380
ap No. 77	Static Pressure = 14.802 psia	P/Pt0= .2986
Tap No. 78	Static Pressure = 14.792 psia	P/Pt0= .2984
Tap No. 79	Static Pressure = 19.494 psia	P/Pt0= .3933
Tap No. 80	Static Pressure = 14.921 psia	P/Pt0= .3010
Tap No. 81	Static Pressure = 14.766 psia	P/Pt0= .2979
Tap No. 82	Static Pressure = 14.777 psia	P/Pt0= .2981
Tap No. 83	Static Pressure = 11.870 psia	P/Pt0= .2395
Tap No. 84	Static Pressure = 12.035 psia	P/Pt0= .2428
Tap No. 85	Static Pressure = 14.678 psia	P/Pt0= .2961
Tap No. 86	Static Pressure = 14.918 psia	P/Pt0= .3010
Tap No. 87	Static Pressure = 16.596 psia	P/Pt0= .3348
Tap No. 88	Static Pressure = 16.397 psia	P/Pt0= .3308
Tap No. 89	Static Pressure = 21.685 psia	P/Pt0= .4375
Tap No. 90	Wall Exhaust Static Pressure = 15.017 psia	
Tap No. 91	Wall Exhaust Total Pressure = 16.998 psia	

Table C-2. (Continued)

************* WAVE CANCELLATION TEST 1 ***************************

al Pressure = 50.171 psia
enum Total Temperature = 60 deg F
bient Pressure = 14.705 psia

ap No. 1	Static Pressure =	50.155 psia	P/Pt0= .9997
ap No. 2	Static Pressure =	16.664 psia	P/Pt0= .3321
ap No. 3	Static Pressure =	16.449 psia	P/Pt0= .3279
ap No. 4	Static Pressure =	16.751 psia	P/Pt0= .3339
ap No. 5	Static Pressure =	16.683 psia	P/Pt0= .3325
ap No. 6	Static Pressure =	17.155 psia	P/Pt0= .3419
ap No. 7	Static Pressure =	16.615 psia	P/Pt0= .3312
ap No. 8	Static Pressure =	17.065 psia	P/Pt0= .3401
ap No. 9	Static Pressure =	17.053 psia	P/Pt0= .3399
ap No. 10	Static Pressure =	17.727 psia	P/Pt0= .3533
ap No. 11	Static Pressure =	18.142 psia	P/Pt0= .3616
ap No. 12	Static Pressure =	18.776 psia	P/Pt0= .3742
ap No. 13	Static Pressure =	18.358 psia	P/Pt0= .3659
ap No. 14	Static Pressure =	17.049 psia	P/Pt0= .3398
ap No. 15	Static Pressure =	16.644 psia	P/Pt0= .3317
ap No. 16	Static Pressure =	17.734 psia	P/Pt0= .3535
ap No. 17	Static Pressure =	18.945 psia	P/Pt0= .3776
ap No. 18	Static Pressure =	18.824 psia	P/Pt0= .3752
ap No. 19	Static Pressure =	18.590 psia	P/Pt0= .3705
ap No. 20	Static Pressure =	18.264 psia	P/Pt0= .3640
ap No. 21	Static Pressure =	17.685 psia	P/Pt0= .3525
ap No. 22	Static Pressure =	17.039 psia	P/Pt0= .3396
ap No. 23	Static Pressure =	15.517 psia	P/Pt0= .3093
ap No. 24	Static Pressure =	18.756 psia	P/Pt0= .3738
ap No. 25	Static Pressure =	18.487 psia	P/Pt0= .3685
ap No. 26	Static Pressure =	17.385 psia	P/Pt0= .3465
ap No. 27	Static Pressure =	16.840 psia	P/Pt0= .3357
ap No. 28	Static Pressure =	16.725 psia	P/Pt0= .3334
ap No. 29	Static Pressure =	16.454 psia	P/Pt0= .3280
ap No. 30	Static Pressure =	16.544 psia	P/Pt0= .3298
ap No. 31	Static Pressure =	15.517 psia	P/Pt0= .3093
ap No. 32	Static Pressure =	14.453 psia	P/Pt0= .2881
ap No. 33	Static Pressure =	19.093 psia	P/Pt0= .3806
ap No. 34	Static Pressure =	17.812 psia	P/Pt0= .3550
ap No. 35	Static Pressure =	16.537 psia	P/Pt0= .3296
ap No. 36	Static Pressure =	16.315 psia	P/Pt0= .3252
ap No. 37	Static Pressure =	16.092 psia	P/Pt0= .3207
ap No. 38	Static Pressure =	16.095 psia	P/Pt0= .3208
ap No. 39	Static Pressure =	15.583 psia	P/Pt0= .3106
ap No. 40	Static Pressure =	15.193 psia	P/Pt0= .3028
ap No. 41	Static Pressure =	13.884 psia	P/Pt0= .2767
ap No. 42	Static Pressure =	15.614 psia	P/Pt0= .3112
ap No. 43	Static Pressure =	15.853 psia	P/Pt0= .3160
ap No. 44	Static Pressure =	15.639 psia	P/Pt0= .3117
ap No. 45	Static Pressure =	15.432 psia	P/Pt0= .3076
ap No. 46	Static Pressure =	15.284 psia	P/Pt0= .3046

Table C-3. Wave Cancellation Test Data

AE CANCELLATION TEST 1 CONTINUED

Tp No. 47	Static Pressure = 15.570 psia	P/Pt0= .3103
Tp No. 48	Static Pressure = 15.085 psia	P/Pt0= .3007
Tp No. 49	Static Pressure = 14.899 psia	P/Pt0= .2970
Tp No. 50	Static Pressure = 14.580 psia	P/Pt0= .2906
Tp No. 51	Static Pressure = 14.599 psia	P/Pt0= .2910
Tp No. 52	Static Pressure = 14.492 psia	P/Pt0= .2889
Tp No. 53	Static Pressure = 14.555 psia	P/Pt0= .2901
Tp No. 54	Static Pressure = 14.243 psia	P/Pt0= .2839
Tp No. 55	Static Pressure = 14.335 psia	P/Pt0= .2857
Tp No. 56	Static Pressure = 14.245 psia	P/Pt0= .2839
Tp No. 57	Static Pressure = 14.020 psia	P/Pt0= .2795
Tp No. 58	Static Pressure = 14.182 psia	P/Pt0= .2827
Tp No. 59	Static Pressure = 13.864 psia	P/Pt0= .2763
Tp No. 60	Static Pressure = 13.773 psia	P/Pt0= .2745
Tp No. 61	Static Pressure = 13.416 psia	P/Pt0= .2674
Tp No. 62	Static Pressure = 13.113 psia	P/Pt0= .2614
Tp No. 63	Static Pressure = 12.470 psia	P/Pt0= .2486
ap No. 64	Static Pressure = 12.745 psia	P/Pt0= .2540
ap No. 65	Static Pressure = 12.574 psia	P/Pt0= .2506
ap No. 66	Static Pressure = 12.887 psia	P/Pt0= .2569
ap No. 67	Static Pressure = 12.829 psia	P/Pt0= .2557
ap No. 68	Static Pressure = 12.550 psia	P/Pt0= .2502
ap No. 69	Static Pressure = 12.114 psia	P/Pt0= .2415
ap No. 70	Static Pressure = 11.676 psia	P/Pt0= .2327
ap No. 71	Static Pressure = 9.998 psia	P/Pt0= .1993
ap No. 72	Static Pressure = 16.368 psia	P/Pt0= .3263
ap No. 73	Static Pressure = 15.767 psia	P/Pt0= .3143
ap No. 74	Static Pressure = 13.778 psia	P/Pt0= .2746
ap No. 75	Static Pressure = 16.514 psia	P/Pt0= .3292
ap No. 76	Static Pressure = 16.422 psia	P/Pt0= .3273
ap No. 77	Static Pressure = 14.709 psia	P/Pt0= .2932
ap No. 78	Static Pressure = 14.764 psia	P/Pt0= .2943
ap No. 79	Static Pressure = 16.071 psia	P/Pt0= .3203
ap No. 80	Static Pressure = 14.792 psia	P/Pt0= .2948
ap No. 81	Static Pressure = 14.720 psia	P/Pt0= .2934
ap No. 82	Static Pressure = 14.733 psia	P/Pt0= .2937
ap No. 83	Static Pressure = 11.830 psia	P/Pt0= .2358
ap No. 84	Static Pressure = 12.269 psia	P/Pt0= .2446
ap No. 85	Static Pressure = 14.632 psia	P/Pt0= .2916
ap No. 86	Static Pressure = 14.835 psia	P/Pt0= .2957
ap No. 87	Static Pressure = 16.368 psia	P/Pt0= .3263
ap No. 88	Static Pressure = 16.315 psia	P/Pt0= .3252
ap No. 89	Static Pressure = 14.034 psia	P/Pt0= .2797
ap No. 90	Wall Exhaust Static Pressure = 14.707 psia	
ap No. 91	Wall Exhaust Total Pressure = 15.200 psia	

Table C-3. (Continued)

************ WAVE CANCELLATION TEST 2 ***************************

al Pressure = 50.336 psia
num Total Temperature = 61 deg F
ient Pressure = 14.676 psia

ap No. 1	Static Pressure = 50.349 psia	P/Pt0=1.0003
ap No. 2	Static Pressure = 16.752 psia	P/Pt0= .3328
ap No. 3	Static Pressure = 16.560 psia	P/Pt0= .3290
ap No. 4	Static Pressure = 17.162 psia	P/Pt0= .3409
ap No. 5	Static Pressure = 16.824 psia	P/Pt0= .3342
ap No. 6	Static Pressure = 17.170 psia	P/Pt0= .3411
ap No. 7	Static Pressure = 16.758 psia	P/Pt0= .3329
ap No. 8	Static Pressure = 17.198 psia	P/Pt0= .3417
ap No. 9	Static Pressure = 17.173 psia	P/Pt0= .3412
ap No. 10	Static Pressure = 17.900 psia	P/Pt0= .3556
ap No. 11	Static Pressure = 18.385 psia	P/Pt0= .3652
ap No. 12	Static Pressure = 19.033 psia	P/Pt0= .3781
ap No. 13	Static Pressure = 18.514 psia	P/Pt0= .3678
ap No. 14	Static Pressure = 17.773 psia	P/Pt0= .3531
ap No. 15	Static Pressure = 16.724 psia	P/Pt0= .3322
ap No. 16	Static Pressure = 18.009 psia	P/Pt0= .3578
ap No. 17	Static Pressure = 19.146 psia	P/Pt0= .3804
ap No. 18	Static Pressure = 18.920 psia	P/Pt0= .3759
ap No. 19	Static Pressure = 18.743 psia	P/Pt0= .3724
ap No. 20	Static Pressure = 18.276 psia	P/Pt0= .3631
ap No. 21	Static Pressure = 17.848 psia	P/Pt0= .3546
ap No. 22	Static Pressure = 18.091 psia	P/Pt0= .3594
ap No. 23	Static Pressure = 16.828 psia	P/Pt0= .3343
ap No. 24	Static Pressure = 18.899 psia	P/Pt0= .3755
ap No. 25	Static Pressure = 18.785 psia	P/Pt0= .3732
ap No. 26	Static Pressure = 17.424 psia	P/Pt0= .3462
ap No. 27	Static Pressure = 16.978 psia	P/Pt0= .3373
ap No. 28	Static Pressure = 16.851 psia	P/Pt0= .3348
ap No. 29	Static Pressure = 16.760 psia	P/Pt0= .3330
ap No. 30	Static Pressure = 16.951 psia	P/Pt0= .3368
ap No. 31	Static Pressure = 15.866 psia	P/Pt0= .3152
ap No. 32	Static Pressure = 15.695 psia	P/Pt0= .3118
ap No. 33	Static Pressure = 19.442 psia	P/Pt0= .3862
ap No. 34	Static Pressure = 17.935 psia	P/Pt0= .3563
ap No. 35	Static Pressure = 16.684 psia	P/Pt0= .3315
ap No. 36	Static Pressure = 16.444 psia	P/Pt0= .3267
ap No. 37	Static Pressure = 16.535 psia	P/Pt0= .3285
ap No. 38	Static Pressure = 16.483 psia	P/Pt0= .3275
ap No. 39	Static Pressure = 16.644 psia	P/Pt0= .3307
ap No. 40	Static Pressure = 15.738 psia	P/Pt0= .3127
ap No. 41	Static Pressure = 15.335 psia	P/Pt0= .3047
ap No. 42	Static Pressure = 15.728 psia	P/Pt0= .3125
ap No. 43	Static Pressure = 16.211 psia	P/Pt0= .3221
ap No. 44	Static Pressure = 16.026 psia	P/Pt0= .3184
ap No. 45	Static Pressure = 16.446 psia	P/Pt0= .3267
ap No. 46	Static Pressure = 16.124 psia	P/Pt0= .3203

Table C-3. (Continued)

ap No. 47	Static Pressure = 15.848 psia	P/Pt0= .3148
ap No. 48	Static Pressure = 15.859 psia	P/Pt0= .3151
ap No. 49	Static Pressure = 15.710 psia	P/Pt0= .3121
ap No. 50	Static Pressure = 15.425 psia	P/Pt0= .3064
ap No. 51	Static Pressure = 14.896 psia	P/Pt0= .2959
ap No. 52	Static Pressure = 15.249 psia	P/Pt0= .3029
ap No. 53	Static Pressure = 15.246 psia	P/Pt0= .3029
ap No. 54	Static Pressure = 15.099 psia	P/Pt0= .3000
ap No. 55	Static Pressure = 15.028 psia	P/Pt0= .2986
ap No. 56	Static Pressure = 14.890 psia	P/Pt0= .2958
ap No. 57	Static Pressure = 14.843 psia	P/Pt0= .2949
ap No. 58	Static Pressure = 14.459 psia	P/Pt0= .2873
ap No. 59	Static Pressure = 14.608 psia	P/Pt0= .2902
ap No. 60	Static Pressure = 14.004 psia	P/Pt0= .2782
ap No. 61	Static Pressure = 13.721 psia	P/Pt0= .2726
ap No. 62	Static Pressure = 13.776 psia	P/Pt0= .2737
ap No. 63	Static Pressure = 12.873 psia	P/Pt0= .2557
ap No. 64	Static Pressure = 12.900 psia	P/Pt0= .2563
ap No. 65	Static Pressure = 13.171 psia	P/Pt0= .2617
ap No. 66	Static Pressure = 13.469 psia	P/Pt0= .2676
ap No. 67	Static Pressure = 12.649 psia	P/Pt0= .2513
ap No. 68	Static Pressure = 12.940 psia	P/Pt0= .2571
ap No. 69	Static Pressure = 12.815 psia	P/Pt0= .2546
ap No. 70	Static Pressure = 11.841 psia	P/Pt0= .2352
Tap No. 71	Static Pressure = 9.579 psia	P/Pt0= .1903
Tap No. 72	Static Pressure = 16.434 psia	P/Pt0= .3265
Tap No. 73	Static Pressure = 15.814 psia	P/Pt0= .3142
Tap No. 74	Static Pressure = 14.184 psia	P/Pt0= .2818
Tap No. 75	Static Pressure = 16.604 psia	P/Pt0= .3299
Tap No. 76	Static Pressure = 16.639 psia	P/Pt0= .3306
Tap No. 77	Static Pressure = 14.679 psia	P/Pt0= .2916
Tap No. 78	Static Pressure = 14.679 psia	P/Pt0= .2916
Tap No. 79	Static Pressure = 16.368 psia	P/Pt0= .3252
Tap No. 80	Static Pressure = 14.712 psia	P/Pt0= .2923
Tap No. 81	Static Pressure = 14.659 psia	P/Pt0= .2912
Tap No. 82	Static Pressure = 14.663 psia	P/Pt0= .2913
Tap No. 83	Static Pressure = 12.258 psia	P/Pt0= .2435
Tap No. 84	Static Pressure = 12.840 psia	P/Pt0= .2551
Tap No. 85	Static Pressure = 14.618 psia	P/Pt0= .2904
Tap No. 86	Static Pressure = 14.763 psia	P/Pt0= .2933
Tap No. 87	Static Pressure = 16.535 psia	P/Pt0= .3285
Tap No. 88	Static Pressure = 16.398 psia	P/Pt0= .3258
Tap No. 89	Static Pressure = 14.060 psia	P/Pt0= .2793

Table C-3. (Continued)

LIST OF REFERENCES

1. Demo, W. F., Cascade Wind Tunnel for Transonic Compressor Blading Studies, MSNE Thesis, Naval Postgraduate School, Monterey, CA, June 1978

2. Arnold, M. J., and Fjelde, J. A., Preliminary Calibration of a Cascade Wind Tunnel, AE 3815 Laboratory Report, Department of Aeronautics, Naval Postgraduate School, Sept. 23, 1978.

3. Zucker, R. D., Fundamentals of Gas Dynamics, Matrix Publishers, Inc., 1977.

4. North Atlantic Treaty Organization Advisory Group for Aerospace Research and Development Report AGARD-LS-39-70, Supersonic Cascade Performance, by H. Starken and H. Lichtfuss, August 1970.

5. Goethert, B. H., Transonic Wind Tunnel Testing, Pergamon Press, 1961.

6. Arnold Engineering Development Center Report AEDC-TR-60-9, A Summary of Perforated Wall Wind Tunnel Studies at the Arnold Engineering Development Center, by M. Pindzola and W. L. Chew, August 1960.

7. Bruhn, E. F., and others, Analysis and Design of Flight Structures, Tri State Offset Company, 1965.

8. Geopfarth, R. N., Development of a Device for the Incorporation of Multiple Scanivalves into a Computer-Controlled Data System, MSAE Thesis, Naval Postgraduate School, Monterey, CA, March 1979.

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